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E. L. Demmon, Director

New Orleans, La.

AN INQUIRY INTO THE COSTS OF TRACTOR LOGGING IN SOUTHERN PINE

by

Robert E. Worthington,
Associate Forest Economist.

September, 1937.

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I. INTRODUCTORY

1. Tractor-skidding at Crossett, Arkansas.-This paper reports an inquiry[1] into the costs of tractor logging in the Southern pine region. Much of the investigation was carried on at the Crossett Lumber Company of Crossett, Arkansas, in the spring of 1936. Here at the suggestion of the Branch of

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[1] Acknowledgment is due to the private cooperators - the Crossett Lumber Company and the Caterpillar Tractor Company. Special credit is due to the following men of the Branch of Research, U. S. Forest Service, for their aid in initiating and completing the inquiry: Burt P. Kirkland, Principal Forest Economist of the Washington Office, for conceiving the project and interesting the two private cooperators in the plan and for the general plans of woods work and office analysis; Axel J. F. Brandstrom, Pacific Northwest Forest Experiment Station, for supplying the analysis methods, preparing the preliminary hourly operating costs and advice in the early field work; Francis X. Schumacher, formerly in charge of Office of Forest Measurements (since July 1, 1937, Professor of Forestry, Duke University) and Roy A. Chapman, Southern Forest Experiment Station, for their guidance in the office analysis; P. R. Wheeler, Southern Forest Experiment Station, for his help in planning and his supervision of assembling the information on Hollerith cards; and Joseph Yensco, formerly of the Southern Forest Experiment Station for his assistance in conducting the woods work. Acknowledgment is also due to C. F. Hunn, Editor of the Branch of Research, Forest Service, for his help in arranging the tables and figures.

Research, U. S. Forest Service, the Caterpillar Tractor Company of Peoria, Illinois, contracted with the lumber company to log an area of the latter's holdings at a graduated price per M board feet, depending upon the distance from the railroad. The contract called for delivery of the logs from the stump to the logging railroad. Felling and bucking into tree-length logs in the woods; bucking into short logs (12-20 feet long) at the railroad; loading and rail delivery to the mill at Crossett were to be done by the lumber company.

The Southern Forest Experiment Station, Branch of Research of the U. S. Forest Service, agreed as its part of the cooperative project to make records while the job progressed which would permit a report of output and costs upon the completion of the project. The fundamental objective of the logging report was to be the preparation of estimates of logging cost for specified tree-size and lengths of haul for the various methods and types of equipment. In pursuit of this objective a 320-acre tract was logged at Crossett. The timber removed consisted of loblolly and shortleaf pine and several species of hardwoods which were commercially usable in that locality and site. Most of the timber was from second-growth and old-field stands though about 90 acres were classed as old growth. The number of trees and their volumes by species groups cut from the 320-acre tract at Crossett were as follows:

		Shortleaf and Loblolly pine	Hardwoods	Total All Species
Sawlog trees (number)		4,494	665	5,159
Cubic-foot volume excluding bark	(cu.ft.)	211,515	28,589	240,104
Board-foot volume (Doyle-Scribner[1])	(bd.ft.)	1,226,865	171,141	1,398,006
do (Scribner Dec. C)	(do)	1,335,620	179,070	1,514,690
do (Int.-1/4-in.kerf)	(do)	1,501,376	198,815	1,700,191

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[1] Doyle-Scribner scale, used quite generally in the South for contract labor payments and for log sales, combines the lower values of the Doyle and the Scribner log rule. For log diameters of 28 inches and less the Doyle rule gives the lower values; for logs of larger diameters the Scribner log rule gives lower values. In the present report output is measured in units of 100 cu. ft.; M (or 1000) board feet, by Doyle-Scribner scale; Scribner Decimal C and International ($\frac{1}{4}$-in. kerf) scale. Scribner Decimal C scale is standard for U. S. Forest Service sales and the International scale gives estimates of board foot volume which closely approximate lumber tally.

The Caterpillar Tractor Company furnished 4 new tractors, 3 of which were Diesel-powered, and 2 fairlead arches for the experiment. All the labor used with the exception of a tractor driver was hired locally.

2. Other logging investigations.-In the fall of 1936 the Southern Forest Experiment Station conducted a series of shorter investigations in tractor logging in the southeastern section of the United States. The companies whose operations formed the basis for the investigations were:

Jackson Lumber Company of Lockhart and W. T. Smith Lumber Company of Chapman, Alabama; Brooks-Scanlon Corporation of Foley, Florida; and Pearl River Valley Lumber Company of Canton, Mississippi. The completion of the woods work occurred with a brief investigation of the costs and output of team-skidding with low-wheeled bummer in the woods of the Crossett Lumber Company at Crossett.

This series of investigations was confined mainly to skidding in pine.[1] Truck transportation of logs as a competitor of skidding by animals

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[1] The information obtained at the W. T. Smith Lumber Company dealt wholly with bunching logs and loading trucks with a so-called "Speeder Loader", a crane mounted on a Diesel 40 Caterpillar tractor.

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or tractors is extensively used in the South. Truck logging has been the subject of inquiry by R. R. Reynolds of the Southern Forest Experiment Station and a report is in preparation. A comparison of the results of these reports should aid in the determination of the proper limits of skidding and trucking distances when weather, type of ground and other factors permit the use of trucks.

3. <u>Reasons for starting tractor logging in the spring wet season</u>.-April was chosen by the three cooperators as the season desirable in which to start the logging experiment at Crossett for two purposes. One purpose was to provide the lumber company with logs when it was thought that there would be a spring shortage due to the relative inactivity of truck and animal logging during the winter months. The second purpose was to test the

adaptability of tractor logging to this locality in the wet as well as in the dry season. The logging period was planned to extend well into dry weather. The second purpose was not fulfilled because the spring of 1936 was an abnormally dry season. The logging was interrupted because of rain on but one occasion (no one works in the open during an Arkansas rainstorm). Dry weather conditions prevailed throughout the 70-day period of logging insofar as the character of the footing afforded the tractors. If judged by the results of the present project, conjecture must prevail, as it has in the past, on the question of how efficiently tractors can operate during the Crossett wet season when trucks and teams are forced to remain idle.

4. List of separate cases.-A list of the separate experiments, referred to in the present report as "cases", follows:

Equipment and Operator		Type of Haul[1]
Arch-skidding tractors		
Case A-1; RD 7; Caterpillar Tractor Co. at Crossett, Ark.		S. to R.R.
Case A-2; do ;	do	B.P. to R.R.
Case A-3; Diesel 50; Brooks-Scanlon Corp. at Foley, Florida		S. to R.R.
Case A-4; RD 6; Caterpillar Tractor Co. at Crossett, Ark.		do
Pan-skidding tractors		
Case B-1; RD 7; Brooks-Scanlon Corp. at Foley, Florida		do
Case B-2: RD 6; Jackson Lumber Co. at Lockhart, Alabama		do
Ground-skidding tractors		
Case C-1; RD 6; Caterpillar Tractor Co. at Crossett, Ark.		do
Case C-2; McC.-D. Diesel 40; Pearl River Valley Lbr. Co. at Canton, Miss.		do
Case C-3; RD 4; Caterpillar Tractor Co. at Crossett, Ark.		do
Case C-4; do ;	do	S. to B.P.
Case C-5; Gas 30;	do	do
Other equipment		
Case D-1; Team with bummer; Crossett Lumber Co. at Crossett, Ark.		S. to R.R.
Case D-2; Speeder Loader; W. T. Smith Lbr. Co. at Chapman, Alab.		Loading trucks
Case D-3; Barnhardt Car-top loader; Crossett Lbr. Co. at Crossett, Ark.		Loading cars

[1] S = Stump; R.R. = Railroad; B.P. = Bunching point.

5. <u>General considerations</u>.-All the cases reported in the present paper dealt with seasoned logging equipment and crews with the exception of tractor-skidding by the Caterpillar Tractor Company at Crossett. Of the remaining cases, the RD 6 Caterpillar tractor and pan operating at the Jackson Lumber Company represented the most recent installation; the equipment had been at work for 10 months prior to the investigation. Skidding with tractors at the Brooks-Scanlon Corporation and the Pearl River Valley Lumber Company had been started several years previous; bunching and loading with the Speeder Loader at W. T. Smith Lumber Company was of at least a year's duration prior to the inquiry. Skidding with teams and loading with the Barnhardt car-top loader were essentially unchanged methods for years at the Crossett Lumber Company. In a later section of the present report when the results are analyzed, attention is called to certain features wherein seasoned crews appeared to work more efficiently. It is reasonable to expect such situations to arise; efficiency in management and workmanship is acquired only by thought and experience.

The piece-rate system of labor payment prevailed in tractor-skidding at the Jackson Lumber Company and team-skidding at the Crossett Lumber Company; all the other labor was paid on an hourly basis.

II. LOGGING EQUIPMENT AND METHODS

6. <u>Size and type of logging equipment</u>.-Reference to the photographs and glossary at the end of this report will aid in the following descriptions. All of the tractors reported in this paper were of the crawler type. Table 1 shows some of the characteristics of these machines. The drawbar horsepower and shipping weight give an index to their relative effectiveness

and size. As shown in table 1, all of the tractors were built by the Caterpillar Tractor Company, with one exception, the McCormick-Deering (International Harvester) Diesel 40 used at the Pearl River Valley Lumber Company. With the exception just noted, the machines were equipped with winches, drums holding 80 feet or more of wire rope. The winches were powered by the tractor engines and were capable of exerting a pull considerably in excess of that from the drawbar of the tractors.

7. Tractor-skidding methods.-In ground-skidding, the logs were attached to the drawbar of the tractor or to the winch line or to both by means of tongs[1] or chokers. No auxiliary device was used to minimize the "drag" or friction of the logs. In pan-skidding, a piece of boiler plate termed a pan, flared up at the front, was hooked to the drawbar of the tractor. The logs were attached as with ground-skidding. Relatively little care was necessary to insure the logs riding with their front ends upon the pan as they would tend to assume this position when the tractor started. The use of a pan reduced the drag of the load and eliminated the hang-ups which might readily have occurred on stumps or other obstructions if ground-skidding were employed. Either of these types of skidding may be used without winches.

In arch-skidding, a fair-lead arch was fastened to the drawbar of the tractor with a universal-joint type of coupling. The third piece equipment necessary for this type of skidding was the winch. The line from the winch, mounted on the rear of the tractor, was threaded through the fair-lead on the top of the arch. The logs were attached to the hooks at

[1] Tongs were used only at Crossett; the type selected was not satisfactory.

the end of the winch line by means of chokers. When a load of logs was hooked the winch line was wound in over the arch fair-lead until the front ends of all the logs were clear of the ground; after the winch was locked by a brake to prevent the line paying out, the load was ready for its trip. Log friction by this method of skidding was reduced over that of the other methods. More logs could be carried because the winch line, threaded through the fair-lead on the top of the arch, permitted the building up the load in successive layers.

The types of haul for tractor skidding were three: Type 1, skidding from the stump to a bunching point or windrow in the woods as a preliminary step in the trip to the landing. This method was used only by the Caterpillar Tractor Company at Crossett. Type 2, skidding from the stump to the railroad was the method most generally employed. Type 3, skidding from the bunching point to the railroad was naturally linked with type 1 and therefore was employed only at Crossett. A method mid-way between these types was used in pan-skidding at the Jackson Lumber Company. A teamster with a team of mules did partial bunching for the tractor. In some instances his work consisted of swinging the logs, in others he moved the logs a few feet or rolled them over to allow easy access for the chokers. The practical effect was to provide a lane of logs along which the tractor could move collecting its load as it went. Hooking time was minimized and yet bunching cost was not high. The relatively small size of the timber enabled a mule team to do this work the more readily. The timber was scattered, for this reason hooking time would have been much higher if the tractor had been driven within reach of each tree.

8. Team-skidding.-In team-skidding at the Crossett Lumber Company, a bummer equipped with low solid-wood wheels was used as a support for the log, only one of which was skidded in a trip. The team was driven to the log, the bummer was unhooked from the whiffletree and raised to an upright position beside the log by the teamster; the axis of the bummer axle parallel to that of the log. The two doghooks were set in the log and the team was hooked to the bummer. The pull of the team righted the bummer and swung the log to its position on the bunk where it was firmly held by the two hooks. The skidding distance with this type of equipment did not exceed 400 feet. At Crossett greater distances than this, where animal power was used, were negotiated by 4- or 8-wheel wagons. Unfortunately, no investigation was made of this type of haul. The wagons had been laid up for the wet season when the chance presented itself to record their performance.

9. Truck-loading with Speeder Loader.-The W. T. Smith Lumber Company operated two "Speeder Loaders" for bunching logs and loading motor trucks in its logging. The Caterpillar tractor[1] was the base and furnished the power. The loader was equipped with a boom capable of swinging through a full circle. The setup of boom, drums and lines was that of the usual dragline shovel widely used for dirt moving. At the end of the boom line (to use dragline shovel terms) a pair of tongs was fastened. Loading was done with them. In bunching the boom line was also used. The tongs and line were carried out and fixed to the log to be dragged to the machine.

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[1] The loader whose output is recorded here was mounted on a Diesel 40 Caterpillar tractor; the other loader had an RD 6 Caterpillar tractor as a base.

In cases where the large size of the log prevented its being moved by the boom line alone, the dragline was payed out and hooked to the log. Ordinarily the dragline saw no service, loading and bunching was done with the boom line. The loader moved through the woods loading the trucks as they arrived. While waiting for trucks the logs lying within 75-100 feet on either side of loader's path were bunched to a point within easy reach for loading. The logs could be readily placed in piles because the boom line was threaded through the top of the boom which gave a "lead" far higher than any pile the loader would be apt to build. A 20-foot lead from the top of the boom made bunching easy as the power exerted on the log was a "lift" as well as a "drag". If the log could not be dislodged the direction of pull could be altered slightly by swinging the boom a few degrees or by moving the loader to a more favorable position.

10. Car-loading with Barnhardt loader.-A record was kept over a period of short-log loading on railroad cars at Crossett with a Barnhardt car-top loader. The logs, delivered by the tractors on the landing along the track, had been cut into the conventional short lengths (generally 10-24 feet). The locomotive, loader and a string of empty cars were sent in for loading. As each load was completed the loader moved over to the next car and loaded the car it had just vacated. The train moved at the intervals required to keep the loader abreast of the logs upon the landing. This loading system when manned by skilled labor is extremely cheap and efficient.

11. Log-lengths hauled.-The tractors skidded tree-length logs. The only major exception to this statement was in the case of the Pearl River Valley Lumber Company. Here 40 feet was the log-length rarely exceeded. However, in estimating skidding time and cost by tree-sizes the Pearl River woods

records were treated as though tree-lengths had been skidded. This apparent contradiction of actual conditions is defended on two grounds: (1) Comparison of this logging job with the others would be unfair if, in effect, we should require the Pearl River tractors to make an extra trip in every 8 or 10[1/] merely because the logging management had elected to

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[1/] Or, what would amount to the same thing in terms of cost, to spend added time in hooking and unhooking the additional logs to maintain the same volume per load.

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hold the log-lengths to 40 feet; and (2) the only practical effect in treating 40-foot logs as tree-length logs is to reduce the upper limit of tree-sizes for which a reliable estimate of skidding time and cost may be made.

The extremely large trees (not more than 40 out of the 5,000) skidded by the Caterpillar Tractor Company at Crossett were bucked into two sawlog-sections at the time of felling. In rare instances at the Jackson Lumber Company two sections were cut from a tree--due to reasons having no relation to tractor skidding. The Brooks-Scanlon Corporation loaded its logs on 48-foot cars so log-length was limited to about 48 or 50 feet. However, in the latter case the timber was so short-bodied that very few trees were cut into two sections in the woods.

The usual short log-lengths were handled with the Speeder Loader at W. T. Smith Lumber Company (case D-2) and with team-skidding and Barnhardt loading at the Crossett Lumber Company (cases D-1 and D-3 respectively). In the office compilation of logging records, the woods conditions were respected. The apparent contradiction with the Pearl River case is explained as follows: though the equipment was capable of handling timber of the

smaller sizes as tree-length logs, the practical limit of tree-length logging, as size increased, would soon be reached. Both loaders (cases D-2 and D-3) were counterbalanced for the lifts usually encountered in short logs and reweighting would be necessary for long-log loading. With team skidding (case D-1), if light loads were not mixed with heavy ones, daily production would fall because animals are capable of meeting severe demands for short periods only. Certainly in the cases of the two loaders it actually would not be practicable to handle long logs without basic changes in trucks and log cars. Of course, the reaches on the motor-truck trailers at Smith (case D-2) could be lengthened readily to accommodate logs of 40- or 50-foot lengths. However, as the logs were dumped in piles along the track for later loading on cars constructed for short logs, there would be no chance to buck the long logs before loading. The Barnhardt loader (case D-3) was loading on cars which would accommodate on the average no log longer than 24 feet (with an overhang, longer logs could be loaded on one car but the car to the front or rear, or both, would have to go to the mill as an "idler" or loaded with logs shorter than usual.

12. Bucking tree-lengths at the landing.-This discussion brings up a point which has fuller treatment in a later section. Because of the car and mill design at Crossett it was necessary to load short logs. Maximum tractor-skidding efficiency was obtainable for practically all tree-sizes when tree-units were skidded. To meet these two requirements it was necessary to buck short logs from the tree-lengths at the railroad. The tractor loads had to be spread at the landing so that each saw-cut was free for bucking. As a result, the available space was filled at least twice as rapidly as on the other skidding jobs where the logs could be ranked side by

side in readiness for loading. At Pearl River (case C-2) the tractors skidded the logs within reach of a jammer which loaded throughout the working day. From the standpoint of skidding efficiency this was ideal, because no logs accumulated to hamper the tractors at the landing. However, unless the jammer was kept reasonably busy loading, the cost of loading was higher than it would have been if the jammer could have set the pace. This feature of proper coordination for maximum efficiency in skidding and loading is beyond the scope of the present report.

III. TRACTS AND SPECIES LOGGED

13. General.-The information gathered for the present report covered a wide range of localities in the South. Of course, the character of the soil and the size and distribution of the timber logged had their effect upon logging cost. The methods used in preparation of the logging cost estimates of the present report are designed to care for variations of timber size as well as skidding distance; there is no provision for the factor of soil nor for the distribution of the timber (that is, whether much or little was logged from an acre). A brief description of each tract is given here; the tracts are grouped as an aid in discussion. Group 1 includes the Crossett Lumber Company tract at Crossett, Arkansas, where both the lumber company and the tractor company were logging; the Pearl River Valley Lumber Company tract near Canton, Mississippi; and the W. T. Smith Lumber Company tract at Chapman, Alabama. Group 2 comprises the Jackson Lumber Company tract at Lockhart, Alabama, and the Brooks-Scanlon Corporation tract at Foley, Florida. For convenience, one could think of group 1 as the shortleaf group and group 2 as the longleaf group.

14. Tracts of the shortleaf group.-There are many outstanding points of similarity in the tracts of the shortleaf group. Both the Crossett and Smith tracts were cut on a tree-selection basis; hardwood as well as pine was logged. Prior to felling, the entire area to be logged had been covered by a man or men who marked with paint the trees to remove. In each case approximately 50 percent of the sawlog volume above a diameter of about 13 inches breast high was marked for cutting. The Pearl River Valley Lumber Company tract near Canton, Miss., produced shortleaf and loblolly pine only - no hardwoods were cut. All trees of a size considered usable were removed. It is quite probable that there was some advantage in gathering a tractor load on this tract because of clear-cutting.

The land surface of the Pearl River tract was flat; at Crossett practically so; and on the Smith tract slightly broken, with sandy hills - whose greatest slope was rarely more than 8 percent - interspersed with broad bottom lands. Prolonged rains of equal intensity upon these 3 tracts would probably render the Crossett and Smith tracts impassable before the Pearl River tract. In the wet season extended use of tractors over the same road would no doubt churn up the soil to such an extent that use of tractors would be out of the question just as trucks and animals are barred from logging in such periods. However, it is believed that of the 3 types of equipment, tractors could be operated at a reasonable rate of efficiency later into the wet period and could resume work sooner than either of the other 2. In other than extremely wet weather, the soil of the 3 tracts may be considered similar with respect to ability to support logging equipment and to offer resistance to dragging logs.

15. <u>Tracts of the longleaf group</u>.-The tracts of group 2, the longleaf group, were alike with respect to species logged and method of cutting. Longleaf pine was the only tree logged and clear-cutting of all merchantable timber was the rule. On the Jackson tract the timber had been cut to a fixed diameter limit about 20 years ago - the present cut was a clean-up one; at Brooks-Scanlon the timber was being cut over for the first time.

In rather sharp contrast to group 1, the timber of group 2 was characterized by smaller individual size and a limited number of trees per acre. As stated under logging methods this condition was partially overcome on the Jackson tract by use of a teamster and mule-team for bunching. The Brooks-Scanlon tract was dotted with "bays" (swamps) impassable to animals and tractors alike. In such instances the winch line was used to pull the logs out to more solid ground.

The soil on the Jackson tract was sandy but of two general types. One of these types was unaffected by moisture so far as efficient tractor operation was concerned; the other soil type was unfavorable to tractor logging during the early spring wet season. Logging in the wet season was largely restricted to the first soil type, during the remainder of the year logging could be done on any of the holdings.

On the part of the Brooks-Scanlon tract where the present cost inquiry took place the soil surface was generally moist[1] and was considered unadapted

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[1] The bays, previously mentioned, occupied a relatively small percentage of the area.

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to truck logging. However, there was a hard subsoil which rendered the tract

suitable to tractor operation. The crawler tracks of the tractor could readily reach firm footing in the muddy places even though this might mean operating at a depth two feet or more below the soil surface. Year-round operation of tractors was the rule.

IV. WOODS RECORDS AND OFFICE COMPILATION

16. Woods-record methods.-Collecting the information for this inquiry was comparatively simple in principle and was performed by men hired on a temporary basis for the period of the work. For each trip of the tractor from the landing to the woods and return the following information was required:

1. Time for trip out (empty)
2. Time for hooking the load
3. Time for trip in (loaded)
4. Time for unhooking the load
5. Delay time of all kinds not chargeable to the first 4 items
6. Number of logs carried in the load
7. Measurements of each log from which volume could be computed
8. Length of haul

One or two observers were assigned to each tractor. A stopwatch, pencil, and notebook were the tools needed for the recording of time, distances were paced from the woods to the nearest point of reference[1/] on

[1/] On this point, usually a stake, the distance to the landing was recorded.

the main tractor road. The logs were usually measured in advance of skidding

by another crew, each log being identified by a number. The distance of haul and the log identifying number were entered upon the record sheet. Woods work for the team and bummer was substantially the same as for the tractors.

In the loading phases of the project, the needed information consisted of the time for the loading of each log and its cubic-foot volume. As in the tractor work, the logs were measured prior to loading; the man who timed the loading recorded each log's identifying number.

The "Speeder Loader" at W. T. Smith Lumber Company bunched logs when not loading trucks. The needed records combined certain features of the tractor information with those of the loader. For each log bunched, the distance it was skidded and the time consumed was recorded. Later when the log was loaded another entry was made on the record sheet. By numbering the log plainly at the time of measurement the recording of its handling was made easy.

For the preparation of hourly costs of equipment actual field records were used wherever practicable. The data of the operators, the Caterpillar Tractor Company and the Pacific Northwest Forest Experiment Station (U. S. Forest Service) were freely drawn upon.

17. Essential elements in computing logging costs.-The tables (nos. 19 through 32) which form the major portion of the present report are built on the plan for logging investigations, now standard in the Forest Service, which contains 3 essential elements. These elements are: (1) The use of 100 cubic feet of wood volume as the unit of volume measurement[1/], (2) the

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[1/] Meaning solid volume (not stacked volume) of wood excluding bark.

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hourly cost for each element of production based upon its main piece of equipment and (3) the equipment-hour or man-hour basis of stating output.

The unit of 100 cubic feet of wood for volume measurement has many advantages. It may be applied equally well to any wood product in the raw state; pulpwood, fuel wood, poles or logs are readily measured in terms of this unit. There is no misunderstanding of the unit used such as might arise where log volume is expressed in board feet by a log rule (none of which is standard throughout the country) or by mill tally. The cord is widely used for measurement of small wood products. The standard cord is defined to consist of a stack of 4-foot wood piled 4 feet high and 8 feet long. Unfortunately, the so-called cord may be made up of wood $4\frac{1}{4}$, $4\frac{1}{2}$, 5 or more feet long, thereby resulting in confusion when the length of the sticks is not stated. The measurement of poles in lineal feet gives no clear idea of the volume they contain. In the present report dealing with the sawlog portion of trees, 100 cubic feet of wood is the standard unit of measurement but volume is also expressed in terms of board feet by 3 log rules. Converting to board feet from cubic feet is by the use of the number of board feet per cubic foot which varies among log rules and also among tree diameters and sawlog lengths for each log rule.

The hourly cost is a simple way of expressing operating expense; tables 4 to 15 are examples. The cost table is divided into 2 main elements: (1) Current operating cost and (2) ownership cost. Item (1) is further subdivided into direct labor cost and other direct cost. All labor necessary for maintaining production with a particular piece of equipment is grouped. Other direct cost comprises such items as direct supplies (for example, fuel and grease) and repair supplies. Repair labor and supervision make up the other main elements in this group. Ownership cost includes such items

as depreciation, interest, taxes and insurance. It is the cost of owning the equipment. When these numerous elements are added the resulting hourly cost measures the expense involved in the use of a piece of equipment. In a logging operation the costs of all phases of production may be shown on an hourly basis. Felling and bucking is one such phase (labor cost is the main item, other cost is nominal), skidding by whatever means, loading and hauling are other phases which may be simply treated by the hourly cost method. The use of a piece-work basis of labor payment does not invalidate this method. Labor earnings over a sufficient period of time form the basis of computing average hourly wage rates suitable for use in an hourly cost table.

Output for any phase of production is readily expressed in terms of the number of hours to produce one unit of volume (for example, in skidding with an RD 7 Caterpillar tractor and skidding pan, the number of hours to skid 100 cubic feet of sawlogs cut from 20-inch trees a distance of 2,000 feet was found to be 0.22 hours - from table 23, A, top portion of table). This rate of output might have been expressed as the number of cubic feet skidded per hour - 456. If desired, the rate of output may be stated this way; to do so, simply divide the tabular values into 100 which is the number of cubic feet taken as the unit of output. However, it is more convenient to express the rate of output as in the table because of the ease of converting the tractor-hour output values to cost per 100 cubic feet (or other unit of volume). At the foot of the page containing table 23 it is stated that the hourly cost of operation of the tractor is estimated to be $3.26. The cost per 100 cubic feet of 20-inch trees skidded 2,000 feet is readily found to be $0.72 (number of hours - 0.22 - multiplied by estimated hourly cost of the tractor and crew - $3.26.) This cost per 100 cubic feet agrees with the

value shown in the lower portion of table 23, A. If we had stated our output as the number of cubic feet skidded per hour, the calculation of cost would not have been so readily perceived.[1] Time and cost of skidding are

[1] Cost calculation would still have been easily done. As stated, the number of cubic feet hauled per hour was 456; the cost of the tractor and crew for an hour's skidding was $3.26; the cost of skidding one cubic foot is obtained by dividing the number of dollars - 3.26 - by the number of cubic feet - 456 - resulting in $0.00716; the cost of skidding 100 cubic feet is 100 times the cost of one cubic foot, or $0.72.

also shown in table 23 in terms of M board feet by 3 log rules. Sections B, C, and D show these values. The number of board feet per cubic foot for 20-inch trees with 35 feet of sawlog length is shown in columns 6, 8, and 10 of table 2. These values are 5.80 for Doyle-Scribner log rule, 6.23 for Scribner Decimal C and 7.09 for International - ¼-inch kerf. The method of preparing the time and cost tables is more fully discussed farther on in this chapter under the heading of analysis of logging information.

18. Hourly cost involved in using logging equipment.-Considerable space is devoted to the discussion of hourly cost for logging equipment. One reason for stressing this phase of the present report is that the equipment used was relatively expensive as compared with equipment for truck and animal logging. Another reason is that tractor logging is a fairly new method in many parts of the South and loggers are apt to be unfamiliar with the expense involved in its use. A third reason for the emphasis upon operating cost is that the main interest of some may be in this particular section; they may

feel that the time and cost tables mean little to them, that the output figures may not be applicable to their operating conditions, while the cost involved in the use of equipment has a real meaning. The discussion here may help in establishing cost records for some who had given the matter little attention before.

19. Summary of hourly cost.-The framework for the display of hourly operating costs as used in the present report has been discussed in general in a preceding section. To summarize, the main elements of which the hourly cost table is composed are (1) Current operating cost and (2) ownership cost. Division (1) is further divided into direct labor cost and other direct cost. In the present section we shall discuss in some detail the various items which are grouped under each of these heads.

Before taking up the separate items in the hourly cost tables, attention is directed to table 3 and figure 1, the latter portraying the data of the former in bar-chart form. The table column headed Men in crew is shown for readily computing cost on a man-hour rather than a machine-hour basis. The man-hour basis of stating performance and cost is useful where it is desired to compare output and cost among unlike phases of production; for example, between felling and bucking, and tractor skidding. For the purposes of this report the equipment-hour basis suffices.

20. Hourly cost adjusted to a common wage base.-The wage rates actually paid to tractor labor are the quantities used in the preparation of hourly cost tables. However, the rates for similar work varied among the cases. To have a common basis for comparing logging cost it is necessary to use like wage rates for similar jobs. As many of the hourly cost tables (7 out

of 12) deal with equipment used in the Crossett area, the wages current there were used to get an "adjusted" total hourly cost for the logging equipment of other localities. These adjusted hourly costs are shown in the last column to the right of table 3. It may be noted that in no case is the hourly cost of equipment greatly increased. If the increase due to using a common wage base is expressed as a percentage of the actual hourly rate we have the following: Case A-3, 5 percent; Case B-1, 6 percent; Case B-2, 15 percent; Case C-2, 9 percent; and Case D-2, 12 percent. It should be emphasized, however, that the costs by tree-size and skidding distance in tables 19-32 are based on the actual hourly costs (not the adjusted ones); figure 6 is the only place in the present report, where adjusted skidding costs are shown though they may be readily computed for any case by multiplying the time required in hours in any table by the adjusted hourly cost for the equipment used.

One point of interest in the adjusted rates is that a rising labor market will not so seriously increase production costs, where equipment is used involving rather heavy ownership cost and current operating cost (other than labor), as in instances where labor cost is the important item. For example, a 20 percent rise in wage rates would greatly increase the hourly cost for case D-3 (Barnhardt car-top loader) because 65 percent of the total is paid to labor; for the other extreme in table 3, a 20 percent increase in wage rates would not increase the hourly cost for case A-3 nearly so much because labor receives only 20 percent of the total for this equipment.

The bar chart, figure 1, is an aid to easy comprehension of the material in table 3. A glance at the chart will disclose differences which otherwise are not readily noted. The series of tables, nos. 4-15, may be inspected for the makeup of the hourly costs.

21. Direct labor cost.-In the labor division of the hourly cost, the compensation paid the workmen was the important item, the remainder was 3.3 percent of the payroll for industrial and unemployment insurance. This percentage was the amount reported by the Crossett Lumber Company in the spring of 1936. For the sake of uniformity the same share was charged to all equipment throughout the project irrespective of locality. In case B-2 and case D-1 (tables 8 and 13) payments to labor were made on a piece-rate basis. These contract payments were treated as hourly rates, however, by dividing the amount paid labor over a period of time by the number of hours actually worked.

22. Other direct cost.-Other direct cost in the hourly cost tables consists of many items. Strict account was kept of these for the tractor-skidding done by the Caterpillar Tractor Company at Crossett. The consumption of fuel, oil, grease, and gasoline as well as the amount of service labor may be relied upon for this set of conditions. These respective items for the other tractor-skidding cases were estimates from the owners tempered if needed by the previous experience at Crossett. These items ranged from 8 to 16 percent of the total hourly cost for the tractors.

23. Cable and rigging cost.-The charge of cable and rigging for the tractors used at Crossett deserves some explanation. When the preliminary hourly cost tables for the tractors were set up at the start of the woods work in 1936 by A. J. F. Brandstrom of the Pacific Northwest Forest Experiment Station (U. S. Forest Service) with the assistance of F. A. Nikirk of the Caterpillar Tractor Company, estimates were made of each item in the hourly cost tables based on data from the Northwest and the long-time records kept by the tractor company engineers. In practically every item but cable and rigging the

estimates slightly exceeded the costs later recorded on the logging job. The actual costs of cable and rigging for the tractors used at Crossett and the preliminary estimates are as follows:

Cost per hour	Cases A-1 and A-2	Case A-4	Case C-1	Cases C-3 and C-4	Case C-5
Winchline (wire rope)	$0.177	$0.192	$0.192	$0.090	$0.250
Butt and choker hooks	.236	.162			
Choker rope (wire rope)	.288	.230			
Skidding tongs			.057	.100	.093
Total cost per hour	0.701	.584	.249	.190	.343
Estimated[1] total cost per hour	.150	.125	.125	.050	.050

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[1] Estimated prior to start of the project.

It is apparent that there is no agreement between actual and estimated cost for cable and rigging. Let us look at the items making up the actual cost. The cost of winch lines could not have been avoided except, perhaps, by using larger sizes, assuming that overloading caused the premature failures. Butt and choker hook cost should have been negligible on these grounds: (1) The butt hooks used were far too light for service and were continually breaking - thereby not only increasing hook cost but cutting production through delay; (2) the Bardon choker hooks used did not fail in service - the charge is for those hooks attached to chokers lost through carelessness. At least a year's hard service is to be expected of the choker hooks.

The cost of choker rope is inordinately high. There are two reasons for this: (1) Failure in service as 5/8 and 3/4-inch chokers were used in

many cases when the work called for 7/8-inch or larger sizes; (2) loss of serviceable chokers in the woods. Most of item (1) and all of item (2) were avoidable with proper supervision and management.

The above statements are based upon the data of table 3a and personal observation of tractor logging in the South and elsewhere. In table 3a are combined the essentials of the cable and rigging records for the Crossett tractor logging and the cable and rigging specifications and cost based upon the statements of the foremen on several logging jobs. In reaching a conclusion on the evidence presented, one must bear in mind that the cable and rigging costs for the tractors used at Crossett are dependable, while the logging foremen's statements from other localities may have contained an element of inaccuracy.

The actual cost for winch lines for the tractors operated by the Caterpillar Tractor Company at Crossett is not equaled in any of the other instances (table 3a). The only comparable instance for large tractors[1]

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[1] The term, large tractors, means tractors 50 h.p. to 65 h.p.; medium tractors 40 to 50 h.p.; small tractors 30 to 40 h.p.

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arch-skidding is case A-3, Brooks-Scanlon Corporation. However, in case A-3, a winch line 3 times as long was used and the logs were winched farther on the average than at Crossett. Even so, the cost figured from the foreman's statement is less than 1/3 that of the large tractor at Crossett. The winch line cost for the Brooks-Scanlon pan-skidding tractor is not comparable because the operating conditions differed radically. Frequently at Brooks-Scanlon the pan-skidding tractor pulled logs from bays 300, 400 or 500 feet beyond the tractor. Seven hundred feet of line was carried and

line cost should be relatively high. Even so the line cost is less than that for the large tractor arch-skidding at Crossett. It should be stated that disregarding other factors arch-skidding provides greater winch-line wear than pan or ground-skidding. The line suspends the heavy load under the arch throughout the trip from woods to landing; in the 2 other types of skidding some or all the logs are usually hooked to the draw bar of the tractor. Winch-line cost for large tractors ground-skidding at Gulf Hammock (see table 3a) was \$0.147 per hour. Operating conditions there were more severe than at Crossett because of the presence of sand and water in parts of the tractor roads.

For choker wire used, we may compare the costs of \$0.288 per hour for tractors at Crossett and \$0.055 at Patterson-McInnes. However, these cases were really not comparable in service because arch-skidding subjects chokers to strains during hooking which are not met by chokers in ground-skidding even when the load hangs-up on a stump or logging debris. When the winch raises the load of 4, 10 or even 12 logs to its place under the arch quite frequently the logs "foul" one another with the result that a single choker may support the weight of 2 or even 4 heavy logs. Of course, such service demands the proper sizes. The lost chokers at Crossett added to the choker wire cost.

This line of reasoning no longer holds when broken butt hooks and lost choker hooks are discussed. The butt hooks used on the tractors at Crossett should have been of size sufficient to stand the strain; the loss of choker hooks attached to chokers could have been reduced to a negligible amount. However, the crews were untrained in caring for their chokers, which was to be expected because other logging methods in the region did not call for rigging regularly detached from the logging equipment; proper supervision could have corrected this loss.

Some of the skidding tong cost is due to broken tongs, the remainder to wear during the period of use. It may be stated that in no case should the cable and rigging cost have risen above \$0.25 per hour for the tractors skidding at Crossett. In the writer's opinion the winch drums used were entirely too small in diameter for satisfactory working life of the winch line wound upon them.

According to a sheet of specifications for the Hyster RD 7 Towing Winch received from the Willamette-Hyster Company of Portland, Oregon, the drum barrel diameter of the winch for the RD 7 Caterpillar tractors is $10\frac{1}{2}$ inches. This is the diameter of the bare drum. The so-called "flange diameter" is $20\frac{1}{2}$ inches - this diameter is for the drum when full of line. The drum is quoted as holding 300 feet of 7/8-inch line or 420 feet of 3/4-inch line. Marks' Mechanical Engineers' Handbook[1/] recommends a minimum

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[1/] Marks, L. S. (editor) Mechanical Engineers' Handbook, 3d edition, 1930, New York, McGraw-Hill, pp. 1066-67.

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drum diameter of 36 inches for 3/4-inch line of 6 x 19 hemp center construction or 22 inches for 3/4-inch line of 8 x 19 hemp center construction.

The "crowding" drum diameter on a No. 4 Northwest shovel is $19\frac{1}{2}$ inches. The diameter of the crowding line spooling on this drum is 3/4-inch. It is fully realized that construction difficulties preclude making winch drums as large as shovel drums; however, even a few inches of increase should be reflected in lessened line wear. Another fruitful source of line wear is the "chewing" of the line when it does not spool properly. Because there is no fair-lead or spooling device for the drum the line is bound to cross in spooling. This condition is hard on line, distorting and flattening

its shape. It is reported[1] that there is device designed to spool line for

[1] Interview with manager of Lorenz Equipment Company, Columbus, Ohio, August 16, 1937.

small drums; whether it is satisfactory in logging service is not known.

In light of this discussion this question might be raised: Why should the tractor logging at Crossett bear the actual cost of cable and rigging if it is inordinately high and if it could be halved or quartered were the logging job repeated? The answer is this: Throughout the office work the objective was to keep as closely as possible in the present report to actual costs incurred. Alternatives frequently had to be weighed as to whether or not to depart from actual costs. For repairs, actual costs were not used; the actual ones were only a fraction of the costs incurred to keep a tractor in working order during its estimated life span. Repair costs on new equipment are negligible but, with added hours of service, breakdowns increase and at intervals general overhauling is necessary.

24. Repair cost.-Of all the current operating costs, repair parts and labor are the items least adapted to estimate from records covering short periods. Reliable information can be obtained from records over the working life of the equipment; even then, one cannot be sure of soundness of the data for application under like conditions. Use and abuse of tractors markedly influence repair costs. Repairs are a minimum when tractors are used on even ground, on soil which is not excessively abrasive to the many track bearings, by a driver who avoids stumps, logs and boulders (and mud and water where possible) and refrains from sudden starts and excessive speed when not

loaded. Careful and frequent lubrication, inspection and adjustments cut the cost of repairs.

Considerable stress in tractor advertising is placed on the ability of these machines to log in rough, rocky and wet situations - places where no other type of logging equipment will work as well, if at all. Repair costs rise rapidly on such logging jobs, particularly when operating through sand and water. In certain logging jobs in the swamplands of western Florida the bearings of the track rollers require lubrication with a water-resistant grease four times daily to hold maintenance costs within reasonable limits. At Crossett the tractors were greased once a day and there was no noticeable wear of the track in the 70-day period.

For all the tractors at Crossett the repair costs given in the hourly cost tables are not the ones incurred on the job. The repair costs incurred on the job are shown in the footnotes of the tables. The repair costs in the tables, greatly exceeding the actual values, are from Caterpillar Tractor Company's long-time records for what is termed heavy service (its classification of operating conditions contains 3 categories - light, medium and heavy). These repair costs appear to be conservative in quantity. For the tractors at the Jackson Lumber Company and the Brooks-Scanlon Corporation (case B-2 and cases A-3, B-1 respectively) the cost accounts of the logging companies were used. Either a separate account was maintained by the company for tractor repairs (case B-2) or repairs were a part of an account including some other items of the element of <u>other direct cost</u>. The repair costs for the Pearl River tractors (case C-2) and Speeder Loader at Smith (case D-2) were estimated using as a basis the type of service and the repair costs established for the other cases. The repair cost for the Barnhardt loader (case D-3) was obtained from the cost accounts of the Crossett Lumber Company.

25. Transportation of crew and supervision.-Transportation of the crew and supervision are the last items in the other direct cost section of the hourly cost tables. The former of these items is designed to cover the expense of carrying the crew to and from work. A train or a truck may be employed for this purpose. Regardless of the means, the expense of operating the conveyance is a proper charge against production cost. In the present cost tables it is an estimated amount placed against each piece of equipment on the basis of the number of men employed. Supervision in the sense used in the present report means immediate supervision. The wages of the foreman in actual charge of the work are covered by the supervision item in the hourly cost tables. Charges for what may be called management, higher up in the organization, is not provided.

26. Ownership cost.-For most of the tractors, depreciation was figured with an estimated working life of 12,000 hours (Brooks-Scanlon, 10,000 hours because of mud and sand). Interest, taxes, fire insurance and uninsured risks were lumped at 10 percent of the average investment.

27. Analysis of logging information.-The analysis of the data to a point where time and cost tables of the report could be prepared was much less simple, more laborious and costly than the work in the woods. A general account of the procedure is given here, together with an example. A knowledge of the methods used is unnecessary for the understanding or use of the tables. At best, the following explanation is unsatisfactory because the more involved steps are not discussed. A complete description of the method used is not within the scope of the present report; it will be the subject of another publication. Those interested in knowing the method thoroughly should consult the author; others may read through this section or ignore it, as desired.

Throughout the office computations the cubic-foot volume of the logs excluding bark was used. Volume in cubic feet is a more nearly true indicator of weight and hence of tractor performance than volume in board feet. As a final step in the preparation of time and cost tables, volumes were expressed in board feet.

About 12 percent by volume of the logs at Crossett were hardwood which were obviously of greater weight than pine. In ground-skidding particularly, a tractor could haul more volume in pine logs than in hardwood. Many loads were of necessity composed of both pine and hardwood. In the office work the hardwood volumes were increased by 23 percent to make them equal pine in weight.[1]

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[1] For example a hardwood log of 52 cubic feet was considered - for purposes of computation - the equal of a pine log of 64 cubic feet. (Green pine is credited with a weight of 52 lbs. per cu. ft.; upland hardwoods at Crossett with 64 lbs. per cu. ft.)

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28. <u>Statistical methods used</u>.-The method, here used, of estimating skidding time for specified skidding distances and tree-sizes was devised by Donald Bruce now of the firm of Mason and Bruce, consulting foresters of Portland, Oregon. The actual working time was recorded in 4 classes: Travel time out (empty), hooking time, travel time in (loaded) and unhooking time. Hooking and unhooking time for each load was combined and treated as one element. Each load usually consisted of logs of different sizes and the skidding distance varied from one load to the next. The hooking and unhooking time for a log of any volume within the range of the information is found

from the hooking and unhooking time per load by least squares.[1] The travel

[1] A mathematical method of finding the most probable value of one quantity (termed the dependent) as related to one or more others (called the independents) by estimation based upon a number of observations of both. In this case hooking and unhooking time per log is estimated from the hooking and unhooking time per load as related to number and volume of the logs in the load.

time out was estimated from the distance travelled by least squares (in this case it was equivalent to plotting time out over distance and reading the estimated values from a line drawn through the plotted points). Where but one log was carried in a load (as in team-skidding with bummer at Crossett) the travel time out to be charged to a load was just that quantity estimated. However, if a load contained more than one log, the time out chargeable to a log is not the estimated time to travel out for a specified distance, each log in the load should certainly not bear the whole time for the empty trip. How much time each log should bear was determined by making an estimate by least squares of the most probable share of a load which is chargeable to logs of any size. If a log of 50 cu. ft., for example, was found as a rule to occupy 25 percent of the load, then it should be charged with 25 percent of the travel time out for any distance. In this way travel out time was found for logs[2] of volumes shown in the time and cost tables.

[2] For most of the studies logs were the full sawlog lengths of trees.

The travel in time chargeable to logs of any volume was determined in this manner: Time for the loaded part of the trip between the woods and the landing was correlated with the distance of travel, for the moment disregarding load volume. Estimates of travel time were then made for each load (these estimates were called the "normal" or "expected" travel times). The actual stopwatch time of travel in for each trip was divided by the normal time corresponding to the length of haul. The "in ratio" resulting from this division was taken to be due to the size of the load. These ratios were submitted to the least squares method of analysis where the independent variables (so-called causitive agencies) were the number of logs and their volumes in each load. The resulting most probable values of the ratios for logs of any volume gave the percent of the normal time for any distance which should be charged to a log of given volume. This ratio or percentage multiplied by the normal travel in time for that distance became the estimate of the travel in time chargeable to a log of specified cubic-foot volume.

The summing of the elements of hooking and unhooking time for a log of a specified volume, the travel out time for a given distance multiplied by the share of the load for a log of that volume and the normal travel in time for that distance multiplied by the <u>in ratio</u> for the log gave the estimated working time for skidding a log from the woods to the landing. Over the whole experiment the sum of the estimated working time should approach the sum of the actual or observed time. To the estimated working time must be added the percentage of delays of all sorts encountered in the actual work. The working time was raised by this percentage. This completed the estimate of skidding time for a log of specified volume for a certain distance. In the time and cost tables of this report time per log (computed in minutes) has been converted to time in hours per 100 cu. ft. for logs of specified

sizes (see upper portion of part A of each table). The lower portion of each section of the tables gives estimated cost which is obtained by multiplying each value of the upper portion by the hourly cost involved in operating the equipment used (see section on hourly rates.) Sections B, C, and D give output and cost in terms of M board feet for 3 different log rules. These values were obtained by using tables of board feet per cubic foot for trees of different diameters and sawlog lengths. These tables were computed for trees of the Crossett study where their contents were computed in cubic feet and board feet by the 3 log rules: Doyle-Scribner, Scribner Decimal C, and International (1/4-inch kerf).

29. <u>Example of preparing a time and cost table for tractor-skidding</u>.-To illustrate how the estimates of time and cost were made for specific distances and tree-sizes one of the cases in the Crossett area logged by the Caterpillar Tractor Company will be treated for a single distance and tree-size. The RD 6 Caterpillar tractor and 6-ton arch skidding from the stump to the railroad (case A-4) is the example selected. We start with the estimated values as obtained from the least squares analyses. The selection of tree size is one of 20-inch diameter breast high and the skidding distance is to be 1,000 feet. Table 2[1], column 5, shows 20-inch trees to contain

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[1] The data for this table were collected at Crossett.

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51 cubic feet (for here logs were handled in tree-lengths) and a skidding distance of 1,000 feet the following values, needed in the calculations, are

tabulated:[1]

(1) Travel out time for 1,000 ft. (minutes) 5.23

(2) Share of the load chargeable to a 51 cu. ft. log .... .208

(3) Travel in time for 1,000 ft. - disregarding volume (minutes) 8.82

(4) Ratio of travel in time with a 51 cu. ft. log to travel in time disregarding volume .... .212

(5) Hook and unhook time per log (minutes) 3.16

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[1] None of the tables in the present report show these figures.

The travel out time chargeable to a 51 cu. ft. log is 1.09 minutes, (1) X (2). The travel in time chargeable to the same log is 1.87 minutes, (3) X (4). The hook and unhook time is 3.16 minutes, (5). The handling time for the log is 6.12 minutes (the sum of the 3 items). To this sum must be added the prorated delay time. From table 17, last column, it is found that with this tractor and arch actual working time was but 83 percent of the elapsed time (that is, 100 - 17). Dividing handling time for the log (that is, 6.12 min.) by 83 percent (the percentage actual working time is to elapsed time) gives 7.37 - the estimated total time for skidding a 51 cu. ft. log for 1,000 feet. It is desirable to express this time in hours per 100 cu. ft. for logs of this size. Dividing by 60 gives 0.123 hours per log; to find the time in hours per 100 cu. ft. it is necessary to divide by the log volume (51 cu. ft.) and multiply by 100. Performing this operation gives us .241 hours per 100 cu. ft. in logs of 51 cu. ft. which agrees with the value for 20-inch trees skidded 1,000 feet in the upper part of table 22, A. The estimated cost of skidding 20-inch trees 1,000 feet is obtained by multiplying .241 by the estimated hourly cost of operating this equipment

($3.27 in the footnote of table 22, A). Multiplying, we get $0.78 which again checks with the tabular value (table 22, A, lower part).

The time and cost may be expressed in terms of hours and dollars per M board feet by any of the different log rules (or mill tally) if the number of board feet per cubic foot is known. In table 2, column 6, for 20-inch trees with an average sawlog-length of 35 feet we find the number of board feet (Doyle-Scribner) per cubic foot to be 5.80. If we divide by the number of board feet per cubic foot and multiply by 10 we may express the time and cost, now in terms of hours and dollars per 100 cubic feet, in hours and dollars per M board feet. Performing these operations give us 0.42 hours and $1.37[1/]. Similar conversions to the M board-foot basis for the Scribner

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[1/] Actually $1.35; when the tables were prepared the hourly values per 100 cu. ft. and per M board feet were prepared first. The hourly values were rounded off to 2 decimal places before figuring the estimated costs.

Dec. C and the International (¼-inch) log rules were made.

30. Variation in method for other logging equipment.-The general procedure just described was followed in the other cases. A variation was introduced in team skidding with bummer at Crossett Lumber Company (case D-1). In this case, one short log[2/] was handled at a time. Then it was necessary to find

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[2/] Lengths from 10-24 feet; average length about 16 feet.

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the average number of short logs in each tree-diameter group. Table 2, column 4, contains these values. For example, the 20-inch trees on the

average contain 2.17 logs; the average short log volume for 20-inch trees is therefore 22.5 cu. ft. (number of cu. ft. per tree, 51, divided by average number of logs per tree, 2.17). Time and cost in each tree-diameter group was computed for the average log within the group[1/].

[1/] This method is valid only when time varies proportionately with log size; if a "curved" relationship were disclosed in the analysis the present method of computing would be only approximately correct.

In the loading experiments the time consumed for loading was correlated with the cubic-foot volume of the log. By this means it was possible to estimate the most probable value of the time required. Of course, this estimated time was not likely to agree with any one of the observations of loading time for that particular log-size (if such observations had been recorded). The estimate would be the most probable value of a series of actual records of loading time for any log-size.

31. Expressing tree volume in terms of diameter.-Before leaving the subject of formation of the time and cost tables one point should have emphasis. The column headings in these tables show tree-diameter as a measure of volume; that is, 12-inch trees, 14-inch trees, etc. These tree-sizes represent the volumes shown in table 2 opposite the corresponding diameter-class. This information was compiled from the measurements taken at Crossett in connection with the present inquiry. It is thought advisable to use these volumes for all the cases of the present report so that a comparison may be made the more readily. If one should want to get time and cost information for trees whose volumes (either cubic-foot or board-foot volumes by any of

the 3 log rules) is markedly differently from that shown in table 2, he can readily attain his objective. On a piece of cross-section paper lay off the vertical scale like that of figures 3, 4, and 5; divide the horizontal scale into volume units (of cubic feet or of board feet by the log rule desired). For 12-inch trees plot the time or cost over the point on the horizontal scale corresponding to 12-inch tree volume which may be found in table 2. Repeat this procedure for other tree-diameter classes. The points should be connected by a smooth curve. Now at a point on the horizontal scale corresponding to the new volume for 12-inch trees one may read from the curve the new time or cost. Values for the other tree-sizes may be read as desired.

32. Scaling the logs.-The volumes upon which table 2 is based are gross volumes; that is, there was no deduction for defects which in ordinary scaling practice would call for a reduction in the scale allowed. The arrangement of the woods work at Crossett permitted a check with local scaling practice for the Doyle-Scribner log rule. The Crossett Lumber Company furnished one of its regular scalers whose duty was to record the delivery of all timber at the railroad as a basis of payment to the Caterpillar Tractor Company under the terms of the logging contract. The scaler faithfully recorded on his scale sheets opposite his scale for each tree the tree-identifying number as marked by the Forest Service. Over all the pine (shortleaf and loblolly) for which this system was applied - practically all of the timber of the experiment - the company Doyle-Scribner scale was about 93 percent of the Forest Service estimate. The agreement is close. Much of the difference can be explained on the following basis. The local scaling practice at Crossett has the two following essentials: (1) Include one bark thickness in measuring diameter and reduce to the lower full inch and

measure the smallest "diameter." The Forest Service found it expedient to take scaling measurements in the woods when the trees were felled. Item (1) was faithfully followed; item (2) could not be observed because the short diameters could not be distinguished before the sawlogs were "broken-out" of their positions in the felled trees. After the logs were dragged to the landing much of the bark was worn off their surface. This would tend to reduce the size of the diameter readings taken by the company scaler. When these points are considered one is justified in the statement that very close agreement prevailed between the scaling by the Forest Service temporary employees and the experienced scaler of the Crossett Lumber Company.

The scaling for board-foot volume by the Scribner Decimal C and the International ($\frac{1}{4}$-inch kerf) log rules followed standard Forest Service practice in so far as diameters inside the bark were recorded for scaling purposes. The diameters were rounded-off to the nearest full inch; for example, a log whose diameter was found to be 10.4 inches was scaled as a 10-inch log; a log whose diameter was 10.7 inches was scaled as an 11-inch log. No timber was scaled in log-lengths of more than 24 feet and rarely more than 20 feet. Though the scaling of the logs took place when they were unbucked units in the total sawlog-length of the tree (true at Crossett for all but the few largest trees), a measuring stick, calipers and bark-thickness gauge provided the means to get an accurate scale.

33. <u>Number of board feet per cubic foot</u>.-The number of board feet per cubic foot, computed from the company scaler's records and the cubic-foot volumes of the Forest Service at Crossett is shown in the following tabulation. Perhaps some would prefer to use these values to express time and cost per M board feet (Doyle-Scribner) rather than the corresponding values

from table 2. At any rate a glance will show the degree of agreement by diameter-classes. As previously stated, the percentage of company scale for pine was 93 percent of Forest Service scale (Doyle-Scribner).

Tree-diameter class	Board feet per cubic foot (Company Doyle-Scribner)
Inches	Number
12	3.34
16	4.44
20	5.32
24	6.01
28	6.54
32	6.76

The values of this table are gross values; that is, they are derived from the company scale for the trees within each tree-diameter class and are not curved to remove unevenness.

V. SKIDDING TIME AND COST BY TREE-SIZE AND DISTANCE

34. General.-Logging in southern pine is not beset with the difficulties of steep topography and adverse weather conditions which occur in some of the other regions of the United States. Wage rates are low in comparison with many of the other regions, a factor which is linked with the comparatively low productivity per man-hour. Labor, probably fully as efficient in the South as elsewhere, is handicapped in effectiveness, as measured in output, by the relatively small size of the timber and few trees per acre. Improvements in logging equipment are as much needed in the South as elsewhere, perhaps the more so because of the extreme scarcity of capital available to many operators in southern logging and milling. Even though labor is cheap, logging

is still expensive when measured in cost per M board feet. As stated in the introductory section all of the cases here reported used seasoned equipment and crews with the exception of the tractor-skidding by the Caterpillar Tractor Company at Crossett.

The tables presented in this section of the report are not designed for ready assimilation and comparison. The showing of time and cost of skidding and loading is on the basis of 4 units of measurement of sawlog volume. This feature complicates the tables but is necessary because of the lack of a universal measurement for sawlog volume. In the interest of clarification and comparison, resort should be made to the figures which present much of the information in graphic form. Ready reference to the corresponding tables for any data of the figures is made possible by the system of case numbers; for example, case A-3 or C-5.

35. Summary of logging information.-As an introduction to the discussion of the logging cost - cost either in time or in money - reference should be made to table 16 which gives a summary of the logging information used in the preparation of the present report. The successive columns show totals or averages for each case. The totals of whatever kind, such as elapsed time, number of trips, show the comparative extent of the study of each case reported. It is not practicable to show a summary of all of the information in a single table. The breakdown of elapsed (total of the working days) time is set out in table 17. From table 16, certain averages are not shown but they can be readily computed, if desired. For example, the average volume per log and average number of logs per trip.

The last two columns to the right in table 16 deserve some discussion; they are entitled average time per 100 cubic feet and average time per 100

cubic feet from table (the term, "table" being explained in a footnote as meaning the appropriate time and cost table). The quantities in the former of these columns were obtained from the data given in table 16. The quantities in the latter column were obtained by interpolation of the time and cost tables; that is, by estimating the time for tree-size[1/] and volume

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[1/] Resort must be made first to table 2 to find the volume in cubic feet corresponding to tree-size expressed in diameter breast high.

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the values of which lie between values given in the time and cost tables. In the former column the woods information was used before being submitted to statistical treatment, in the latter column the average was obtained after the statistical work was done. This comparison furnishes a rough check upon the accuracy of the office work and provides an assurance that no flagrant blunders were committed (of course, each step in the calculations was checked).[2/] The discussion of table 18 is reserved for the present.

[2/] If time required for skidding does not vary proportionately with log- or tree-volume a precise agreement is not possible between the quantities in the 2 columns discussed.

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36. Explanation of make-up of skidding time and cost tables.-The construction of the time and cost tables for specified tree-sizes and skidding distances has been explained in Section 29. A brief description will be given here, however, in the event that section 29 has not been read. Table 19 will be taken as an example. The table has 4 parts: one quarter based on the unit of 100 cubic feet of sawlog volume, another on the unit of M board

feet (Doyle-Scribner), the third on the unit of M board feet (Scribner Dec. C) and the fourth quarter on the unit of M board feet (Int. Scale $\frac{1}{4}$-inch). One of these parts would have served the purpose if a commonly accepted standard for sawlog volume measurement prevailed; however, a single standard does not exist. Each of the 4 quarters of the table is broken down into 2 parts: one showing estimated time required in hours per unit of volume for skidding the sawlog contents of trees of certain sizes for specified distances, the other showing estimated cost in dollars per unit of volume for skidding the sawlog contents of trees of certain sizes for specified distances. The lower half of each quarter of the table is readily obtained from the upper half by multiplying the time required in hours by the hourly rate of tractor and crew. In the case of table 19 the hourly rate is $3.90, as may be seen in the notes at the foot of the table. To be specific, the time required per 100 cubic feet from table 19, A, for skidding 12-inch trees 1,000 feet is 0.43 hours. The cost is $1.68 (found by multiplying the number of hours, 0.43, by the hourly cost for tractor and crew, $3.90). For the sake of clearness it may be stated that the time required per M board feet (Doyle-Scribner) from table 19, B, for skidding 12-inch trees 1,000 feet is 1.23 hours. It must be stressed that the change in hours from table 19, A, to 19, B, is due to change in the unit of volume measure only; that is, from the 100 cubic-foot basis to the M board-foot (Doyle-Scribner) basis. The tree-size and skidding distance, of course, remain the same.

37. Skidding time and cost graphs.-The information given in the time and cost tables by tree-size and skidding distances is shown in graphic form for one case each of arch-skidding, pan-skidding and ground-skidding. Cases A-1, B-1 and C-1 are the ones selected and each is shown as a separate figure; the figure numbers are 2, 3, and 4 respectively. Each one is divided into quarters in order to show time and cost by tree-size classes by the four different schemes of volume measurement used in the present report. Cost in dollars per unit of volume (that is, per 100 cubic feet or per M board feet by any of the 3 log rules) is read using the scale on the left-hand side of any quarter of the figure. Time required may be read using the scale on the right-hand side of any quarter of the figure. The purpose of the charts is comparison and contrast between tree-sizes; the values upon which each is based may be found in the corresponding table of time and cost.

Irrespective of which one of figures 2, 3 or 4 is examined the same general trend is noted of decrease in skidding cost per M board feet or per 100 cubic feet with increase in tree-size. It is, of course, probable that this trend might be reversed if tree-size were greatly increased. If this condition should occur, lower costs could be maintained by bucking the tree-lengths to sizes which could be skidded with greater efficiency. Each curve of the figures is for a specified skidding distance. The lowest curve in each is for hooking and unhooking only. Only the cost of assembling the load in the woods and disengaging it at the landing is included in this item (plus the proper proportion of the cost of delay time). The other curves of each figure (for example, 1,000 feet or 3,000 feet in figure 2) include hooking and unhooking cost as well as skidding cost. Later in the

present report a comparison of hooking and unhooking cost will be made between types of equipment.

While figures 2, 3 and 4 serve their purpose of comparing and contrasting time and cost of skidding by tree-size classes and specified distances within the selected cases (individual experiments), they fall short of providing a basis of comparison between cases. Skipping for the time being figure 5 which will be discussed later, attention is directed to figures 6, 7 and 8 which meet the need of a project-wide comparison of skidding costs. To make this comparison it is necessary to abandon the former scheme of showing tree-size along the horizontal axis of each chart and to substitute skidding distance in its place. A chart is needed for each tree-size group. The five selected are the 12-, 16-, 20-, 24-, and 28-inch groups.

A number of contrasts are apparent from inspection of the figures. Taking figure 6 (12-inch trees) for the present, we note the comparative "isolation" of case B-2 and C-2. Another contrast that appears is the steep slope of the lines for all cases of ground-skidding other than C-2 and for D-1, their comparatively close association, the fairly "gentle" slope of all cases of arch-skidding (the A cases) and pan skidding (the B cases) and the "band" described by the path of all A and B lines save case B-2.

38. The low skidding cost at the Jackson Lumber Company (case B-2).-These well-defined points of likeness and contrast deserve some discussion. The equipment of lowest cost is case B-2 (Jackson Lumber Company) for any distance beyond 2,000 feet and for any tree-size shown in figures 6, 7 and 8. This low-cost relationship may hold for shorter distances but no hauls of less than 1,900 feet were recorded during the period of the test. Based on an inspection of operating conditions one would be inclined to expect costs

as high or higher here than in any of the other cases because of the few trees per acre in the timber stand logged. Even when the hourly cost is adjusted to conform to the common wage base case B-2 still leads. Four points are suggested as possible factors making for low-cost operation in this instance; they are: (1) The use of a bunching team in the woods, (2) almost a year's use of the equipment prior to the test, (3) the contract system of labor payment and (4) the use of a pan rather than an arch in skidding.

The bunching team in the woods was operated at a cost of $0.58 per hour (adjusting the hourly cost by the common wage base gives about $0.80 per hour). The load was assembled in the woods with the bunch-team's help and unhooked at the landing at a lower cost than any of the arch-skidding cases and slightly lower than the other pan-skidding case (B-1). In the ground-skidding cases these costs were equalled and in some cases less but the comparison is not proper between arch- and pan-skidding, and ground-skidding. To show one reason for the preceding statement one is referred to table 18. Footnote 1 should be read along with the table. One is justified in comparing the number of tree-length logs as between tractors though the flat statement should not be made that, if logs of one size alone were hauled, 12, 8 or any other number would be taken in one trip. The table strikingly shows the close agreement of type of equipment with the number of logs per load. The only exceptions are case A-4 and case C-2. The performance of case C-2 will be discussed shortly. Disregarding case C-2 for the moment, it is apparent that a load for a ground-skidding tractor may be obtained in short order and that in all probability the first log hooked need not be disengaged while on the way to pick up the second. For the pan-

and arch-skidding tractors the job of assembling a load particularly of the smaller trees was quite a task and the load was often assembled in 2 to 4 separate units. Usually the first contingents had to be dropped after assembly and picked up again when the last of the load was obtained. The lost motion in such a setup is obvious and tended to increase the hooking and unhooking cost. Apparently the use of a team and teamster in the woods was justified from the cost standpoint for even though the hourly cost was raised 15 percent by use of the team (14 percent in the adjusted hourly rate). It is assumed that the teamster would be required as a helper if the team was not used.

The lack of uncertainty and lost motion was very apparent in the work of the tractor crew in case B-2. The 10-month seasoning of the equipment and crew had much to do with bringing this about. No one seemed to work hard but each step counted. Low costs are expected when every effort is coordinated in the series. Possibly the contract basis of payment helped toward maintaining efficiency. Certainly the workmen had everything to gain by increasing the output.

39. Pan- versus arch-skidding.-Inspection of the information on number of logs per load of table 18 and the hooking and unhooking time and cost of each time and cost table lowers one's estimate of the value of an arch for low-cost skidding. Unfortunately we have no case where a tractor with the same crew was tested with a pan and with an arch under like operating conditions. The nearest approach to a test of this nature was at Brooks-Scanlon where a Diesel 50 Caterpillar was logging with a 10-ton arch and an RD 7 Caterpillar was skidding with a pan under approximately like conditions. For all tree-size classes shown in figures 6, 7 and 8 the pan-skidding was cheaper than

the arch-skidding. Reference to table 18 shows that the logs per load were uniformly less with pan-skidding (case B-1) than with arch-skidding. However, the cost of using a pan is practically negligible while the cost of operating an arch is sizeable - $0.68 per hour for a 10-ton arch. The increase in hourly cost due to the inclusion of an arch in large tractor-skidding equipment is about 20 percent above the cost of a tractor and pan. In no case of the present report does this expenditure appear to have been justified. Final judgment on this point must be reserved.

40. Chokers and tongs for ground-skidding.-Note has already been made of the large number of logs skidded per load by the tractors of case C-2 compared with the ground-skidding tractors used at Crossett. This seems to be another instance where experience in use increased the efficiency. One pair of tongs was generally carried in case C-2 but was rarely used. Chokers were the main dependence for fastening the logs to the tractor. The ground-skidding tractors at the Caterpillar Tractor Company at Crossett used tongs almost exclusively. It is doubtful if tongs are advisable for use with tractors, certainly one size should not have been used for all trees. Much of the delay charged against operating time of the tractors at Crossett in table 17 is attributable to the use of tongs. One source of lost time was the delay occasioned in fixing the tongs at the time of hooking, another source was retonging the logs on the way to the landing because a roll of the log or a sudden jerk of the tractor dislodged the original grip, a third was the time killed by attempting to keep tongs in repair in the woods with a machine hammer and monkey wrench for tools and the railroad track as an anvil. Tongs are indispensable in certain kinds of loading and work very satisfactorily in animal-skidding. Perhaps they would give satisfaction if

properly designed for tractor work with at least 3 sizes constantly at hand for the different diameters of trees encountered. The tractors of case C-2 had no winches; it is believed that production might have been increased through the use of a winch.

When chokers are used in skidding a sure hold on the log is obtained and the load may be built up the more readily. There is a practicable limit to the number of logs which may be attached to a tractor when tongs are used - certainly three would rarely be exceeded.

It is readily apparent from the trend of the cost curves in figures 6, 7 and 8 that an arch, pan or other friction-reducing device is needed for all but the shortest of skidding distances. C-2 is the only case where it appears that low cost would be achieved in ground-skidding as compared with arch- or pan-skidding beyond 1,000 feet. The steepness of the cost curves for the other ground-skidding tractors (and also the horse-skidding case D-1) preclude their competing with arch- or pan-skidding at distances greater than about 600 feet.

41. <u>Team-skidding compared with ground-skidding with tractors</u>.-The sole case of team-skidding with bummer (case D-1) compares quite favorably with the average of the "band" of ground-skidding tractors for distances of 400 feet or less. More extensive investigation would have to be undertaken to make a definite comparison. There are 3 considerations which must be weighed in considering their comparative efficiency: (1) Team-skidding with a bummer is a method long used and the probable ultimate in effectiveness has been reached, the only ground-skidding tractor long in use (case C-2) showed costs for skidding about twenty percent lower than the team; (2) the team work was recorded in late November and early December when temperature

conditions were ideal for animal logging, if the test had been made in hot weather the output per hour in all probability would not have been so great; (3) the teams with bummer are effective for skidding but 400 feet or less.

At Brooks-Scanlon Corporation and at the Jackson Lumber Company no more animals were being acquired for logging. Based on tractor performance over relatively long periods the decision had been made to use tractors in their stead. Animal-skidding for greater distances than about 400 feet at the Crossett Lumber Company calls for the use of wagons; in other southern localities "big-wheels" are often used for longer hauls.

42. The relay system of tractor-skidding.-It should be noted that case A-2 in figures 6, 7 and 8 is not comparable in cost to the other cases. Case A-2 shows the cost of relaying the logs from windrows in the woods to the landing. To this cost must be added the cost of bunching, the first stage in the relay system. How the same tractor and crew can get lower costs by picking up the logs as they lie scattered in the woods than when they are concentrated ready for hauling requires some discussion. In the first place the relay system (from stump to bunching point and from bunching point to railroad) was used almost altogether in the earlier phases of the skidding at Crossett. The equipment was new, the crew was inexperienced in tractor logging. There was a constant shortage of rigging which precluded the pre-setting of all chokers to minimize the hooking time in the woods. All too often raising the load under the arch resulted in broken butt hooks, choker rope or even winchline. If this phase of the test were repeated with rigging properly designed for arch-skidding lower costs would have been achieved.

By the time the relay system was abandoned these difficulties had been partly eliminated, though choker shortage remained a source of inefficiency throughout the tractor-skidding period at Crossett. It is well to stress the point that low hooking cost can be achieved only by planning each load in advance on the part of the helper in the woods who should be the one in authority in the tractor crew. Each choker to be used in the ensuing load should be attached to its log before the tractor and arch arrive for loading. This condition did not exist under the logging of the Caterpillar Tractor Company at Crossett which accounts in some measure for failure to show low skidding costs. In fact, a conservative evaluation of the situation would explain the high costs on these counts: (1) High cable and rigging cost because of improper selection of sizes, loss of chokers and failure to maintain an adequate stock on hand, (2) failure to build up "pay loads" for the ground-skidding tractors because of the use of tongs rather than chokers, (3) vesting the authority for the skidding crew in the driver rather than in his helper in the woods, (4) insufficient landing space at the railroad inefficiently used with no attempts at enlargement. Item (4) did not hinder skidding in cases A-1 and A-2.

It is of interest to know the average length of haul of the ground-skidding tractors in the first stage of the relay system practiced by the Caterpillar Tractor Company at Crossett. Case C-5 (30 hp Caterpillar tractor with winch) was one of the cases; case C-4 (RD 4 Caterpillar tractor with winch) was another. In forty #1[1/] for case C-5 the average length of

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[1/] In the Crossett tractor experiment each forty-acre tract was designated by a number for easy reference and identification.

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haul was 286 feet; in forty #2, 291 feet. Case C-4 occurred in forty #10 only; the average skidding distance was 139 feet. The average number of cubic feet of sawlogs per acre over the entire tract was 750 (derived from table on p. 3 of the present report) and the average volume per load for Case A-2 under the relay was 333 (from table 16). On the average, then, there were at least 2 loads on each acre. As the radius of a circle with an area of 1 acre is but 120 feet, it would appear as though a great number of sawlogs were skidded much farther than was necessary. Probably a skidding distance for bunching of 100-150 feet would rarely have to be exceeded in a timber stand like that at Crossett. The average skidding distance for bunching reported here is much greater than actually required. In all of this discussion of results at Crossett one must bear in mind that the logging done was of an experimental nature. The Caterpillar Tractor Company is entitled to credit for doing a thorough job and making a trial of skidding methods which gave promise of cheap costs. The relay system has merits as shown in case B-2 where a team did the bunching. The writer is of the opinion that short bunching distances and the pre-setting of chokers for the arch-skidding tractor would have made a much better showing in point of cost for the relaying system at Crossett.

43. <u>Hooking and unhooking cost.</u>-Table 33 presents no information not already shown. It is made up of the hooking and unhooking cost of tables 19 to 30, also listed are the loading costs for case D-2 and case D-3 from tables 31 and 32. These latter cases will be discussed in another chapter; they are presented in table 33 for comparison with hooking and unhooking incident to the skidding cases.

Directing one's attention to the cost portion of table 33, it is seen that hooking and unhooking cost of the arch-skidding tractors was markedly higher than for the rest of the equipment; that pan-skidding, ground-skidding and "other equipment" hooking and unhooking costs are about equal if we disregard case D-3 (Barnhardt car-loader).

It is further seen, looking within the groups for likeness and contrast, that hooking and unhooking cost for case A-2 (under the relay system - see section 42) was uniformly less than for case A-1 (the same equipment and crew under the one-stage system of skidding). Case B-2 registers low cost for hooking and unhooking in the smaller diameter-groups and comparatively lower cost throughout all diameter-groups. This may be due in large part to the use of the team for bunching. Case C-2, where chokers were used, shows as low costs as any other tractor. The tongs (used in cases C-1, C-3, C-4 and C-5), on the basis of this table, show low hooking and unhooking cost but 2 factors preclude using this table for final judgment on this score. These factors are: (1) Use of tongs aided in holding the number of logs per load too low for efficient operation and (2) the delay time due to tong trouble is not charged directly against hooking and unhooking in the present report; delays of whatever sort are prorated against each element of cost equally. This latter procedure obscures the significance of the present comparison; the use of tongs really cost more than it would appear from table 33.

Even though full discussion of loading is reserved for another chapter, it is well to point out the loading costs of case D-2 (Speeder Loader, loading trucks at W. T. Smith Lumber Company) for comparison with the hooking and unhooking costs for skidding equipment. From table 33 it would appear that short logs may be loaded on trucks and trailers by a Speeder Loader at less cost than the original tree-length logs could be picked up in the woods by

arch-skidding tractors and unhooked at the landing. As far as the information of the present report would indicate, this generalization is true. The meaning of this comparison will be dealt with later.

Throughout the present section (no. 43) hooking and unhooking cost has been discussed as a unit cost. To give an idea of the relative magnitude of the hooking and unhooking elements which comprise it, the following figures are presented from the woods records:

		Case A-1	Case B-2	Case C-2
Total hooking and unhooking time	(hours)	84.54	12.69	21.80
Total hooking time	do	71.15	9.17	17.39
do	(percent)	85	72	80
Total unhooking time	(hours)	13.39	3.52	4.41
do	(percent)	15	28	20

This information takes no account of size of sawlogs handled; the relatively high proportion of unhooking time for case B-2 seems to indicate efficient hooking rather than high-cost unhooking due probably in part at least to the modified relay system of skidding (the use of a team as an aid in assembling the load in the woods).

VI. COMPARISON OF SKIDDING COST FOR SELECTED CASES IN THE SOUTH, WEST AND EAST

44. General.-A question arises in the reader's mind as to the comparative efficiency of skidding in various forest regions of the country. One acquainted with logging in the big timber of the West is apt to look askance at the comparatively small load volumes and high skidding costs of the present report. The attempt is made in the present chapter to place the skidding data available from several forest regions on a comparable basis. Special credit is due to Axel J. F. Brandstrom, Senior Forest Economist of the Pacific Northwest Forest and Range Experiment Station, for the use of the unpublished information embodied in the present and following chapter. Without his information the comparison would have been much more incomplete.

The output data for skidding equipment for species other than southern pine are expressed in terms of weight per cubic foot and log volume per tree characteristic of the timber measured in the tractor logging at Crossett. The details of the method are not given here. It suffices to say that the output expressed in cubic feet in each species is converted to the equivalent weight in cubic feet of southern pine. The intervals of tree size are the even 2-inch diameter classes for pine at Crossett. For tractor skidding the average log-length was 32 feet; for horse skidding the average log-length was 16 feet or less. These log-lengths corresponded closely with those of the tractor skidding and team skidding at Crossett.

A number of factors present themselves for solution in making a comparison of skidding performance between forest regions, more so than within a region, before a fair case may be presented. A few of these factors are: (1) Wage scales; (2) size and comparative weight of the timber; (3) length of haul; (4) density and distribution of the trees to be skidded and the

presence or absence of timber left standing; (5) lay of the land and character of the soil; and (6) kind of landing and type of loading system. Within reasonable limits it is believed that the first 3 items have been allowed for in the present comparison; the remaining 3 are not taken into account, their presence makes the similarities and contrasts less reliable but by no means renders the present comparison of no value.

45. Hourly costs.-An hourly rate of skidding equipment and the labor used to operate it has been set up for each of the cases reported in the present chapter. The hourly rates for equipment not previously reported are presented in table 34. The method followed is the same for the forepart of the report; the charges for labor are those used for similar positions in the estimate of logging costs incurred by the Caterpillar Tractor Company at Crossett. Where cases are used from previous sections of the present report, the hourly rates have been adjusted (where needed) to bring wages in accord with the "common wage base" (i.e., the wages paid by the Caterpillar Tractor Company and the Crossett Lumber Company for the logging in 1936.)

Charges for items other than labor are the best estimates which could be made for the hypothetical situation. Fuel and lubrication costs are susceptible of fairly accurate forecasting, not only from the records in the actual setting but also because of the performance of similar equipment at Crossett. The cost of cable and rigging is noticeably lower because it is believed that the costs incurred at Crossett could be markedly reduced and do not represent the expense which would be incurred if a year-long period of operation were drawn upon for information.

The hourly costs for horse-skidding equipment are not shown. They do not differ from the hourly cost of case D-1 save that $1\frac{1}{2}$ men are included in the cost for case OD-1.

46. Description of cases.-Figure 9 portrays the skidding performance in terms of cost per unit volume of logs for 15 separate cases. Of these, 5 have already been described. The 10 new ones introduced in figure 9 are here discussed under 3 heads: Arch-skidding tractors, ground-skidding tractors and skidding teams.

Arch-skidding tractors.-There are 4 new cases of arch-skidding, all from Brandstrom. The first, case OA-1, is from gravelly soil and scattered timber with a brushy undergrowth in the Puget Sound region of western Washington in 1931. Gas 60 Caterpillar tractors with fair-lead arches were the equipment used. A complete description of the case is given in the tractor logging section of Brandstrom's report "An analysis of logging costs and operating methods in the Douglas fir region," 1933, published by the Charles Lathrop Pack Forestry Foundation. The logs were loaded by a jammer which straddled the railroad track and kept the landing clear of logs as the skidding progressed.

Reports on cases OA-2, OA-3 and OA-4 have not been published. Each of these is from the ponderosa (western yellow) pine region of eastern Oregon. The slope of the ground was favorable to the load (but the percent of slope is not stated.) With OA-2 and OA-3 a short skidding distance resulted in delays in unhooking the load because the tractors were delivering logs to a fixed landing. The loader, engaged in car-loading, was unable to keep the landing free for unhampered reception of the incoming logs. For this reason, while the record shows the performance under these operating conditions, the logging is not as cheap as would have been possible if the number of pieces of skidding equipment had been limited to the capacity of the car-loader. Brandstrom states in his description of OA-4 that landing delays did not occur. The average skidding distance for case OA-4 was 2230 feet contrasted with 810 feet for OA-2 and 500 feet for OA-3. Of these

cases, only the information for OA-2 is available for estimate of skidding cost for any except the average distance.

Ground-skidding tractors.-No pan-skidding cases are available other than the 2 given in the previous chapters of the present report (cases B-1 and B-2.) Case OC-1, the first new ground-skidding case, occurred in the ponderosa pine of Montana in 1922. A 10-ton Holt was the tractor. The information was taken under summer conditions (that is, with no snow present); the slope of the ground was gentle - from 0-15 percent. The timber was skidded in tree-lengths and bucked to 16-foot lengths prior to loading. Wages were paid on a day labor basis, the case with all of the skidding cases presented here. The timber stand per acre was 15,000 board feet. Case OC-1 is of particular interest inasmuch as it is the earliest available record of tractor performance by distance and timber size in logging among the investigations conducted by the Forest Service.

The remaining 3 ground-skidding cases of the present chapter, OC-2, OC-3 and OC-4, are from eastern Oregon. The timber handled was ponderosa pine. The information at hand for the cases permits no estimate of skidding cost by tree size for any distance but the average. The average distance in each instance was as follows: Case OC-2, 310 feet; OC-3, 280 feet; OC-4, 340 feet. Presumably the ground was level, or practically so, for cases OC-3 and OC-4. Because of blocked landings and time lost by the returning tractors waiting for those under load to pass, these cases have skidding costs higher than would be possible with proper planning of the skidding and loading operations.

Skidding teams.-Cases OD-1 and OD-2 represent instances where teams were employed for skidding. Case OD-1 occurred in white pine logging in southern Maine in 1935. A team, teamster and half time for a swamper, are charged against the operation. The smaller-sized logs handled were skidded

directly to the loading deck to await truck haul to the mill; the larger-sized logs were skidded with a scoot to the loading deck. A scoot is a short sled equipped with a bunk and chains which support the front end of the logs; the rear end of the load drags on the ground in this method of skidding. The average skidding distance was 206 feet; the average log length was between 12 and 16 feet. Case OD-2 deals with ground-skidding 16-foot ponderosa pine logs in eastern Oregon. Logs which were too heavy for one team to skid were moved with the aid of another. The maximum skidding distance was in the neighborhood of 1000 feet; the average skidding distance about 335 feet.

47. Comparison of skidding costs.-Insofar as the comparison of widely divergent skidding conditions as shown in figure 9 is a fair one, the low-cost tractors of the South show up well compared to the cases from the West. Only 6 of the southern cases are shown in figure 9. When the output for western skidding is corrected for the smaller timber size of the South even the lower wages common to southern logging do not reduce the skidding costs of the West to the point of equalling the costs achieved by the most efficient skidding tractors shown in the last chapter of this report. It should be noted that cases B-2 and C-2 are not shown in the 28-inch tree class of figure 9; trees of this size were not available for estimate of their skidding cost.

For ease of comparison like equipment in figure 9 is discussed as a group. Taking the "A" group (arch-skidding equipment) first, the costs of case A-1 compare favorably with the "A" cases from the West. It will be recalled that case A-1 is the low-cost arch-skidding equipment in all but the 12-inch tree class in figures 6, 7, and 8 (case A-2 does not represent complete skidding as it was merely the second and final step in a relay system.) The western skidding equipment showing cost for specified

distances exhibits cost curves roughly parallel to the curve of case A-1, implying that time involved in travel - loaded and empty - resembled that of case A-1 in the South. Unfortunately, for our present purpose skidding cost curves for cases OA-3 and OA-4 are not available.

There are no "B" cases (pan-skidding equipment) available other than those previously reported in the South. The "C" group (ground-skidding equipment) from the West are represented by one case with a cost curve (case OC-1) and 3 cases showing cost for an average distance. The trend of the curve for case OC-1 resembles more nearly that of arch- or pan-skidding tractors. For hauls of 1000 feet or less case OC-1 shows costs well within the lowest third of the costs displayed in figure 9. Cases OC-2, -3, and -4 appear to be less efficient skidding equipment.

The "D" group of cases (team-skidding equipment) is inadequate for generalization. Case OD-2 reports skidding from eastern Oregon, the costs of which are markedly higher than case D-1 (from Crossett.) The slope of the cost curve is very similar to that of case D-1, the usual situation where animals are used for skidding; each increase in length of haul is accompanied by a large increment in skidding cost.

The skidding costs for case OD-1 are for the average distance only and add little to the information of figure 9. Performance for this case is not available in the 28-inch tree groups but as skidding cost is rising comparatively rapidly through the 20- and 24-inch groups the presumption is that costs in the 28-inch group would be too high for consideration.

To sum up the discussion of figure 9, it may be said that though the cases from other parts of the country vary considerably in performance, their skidding costs on the whole are higher than those reported from the South in the previous chapter.

48. Scope of the log-loading information.-The information obtained on log-loading in the woods work of the present inquiry was limited to 2 cases - cases D-2 and D-3. Case D-2 dealt with the loading of trucks and trailers in the holdings of the W. T. Smith Lumber Company, of Chapman, Alabama, in November 1936. A Speeder Loader[1] bunched logs and loaded trucks and trailers in the woods. The other case of log-loading recorded the performance of a Barnhardt steam loader, case D-3, loading cars at Crossett. The logs loaded were some of those from the tractor area supplemented with logs brought to the railroad by truck loggers under contract with the Crossett Lumber Company. While the present report was being written information on 5 mechanical loaders operating in the ponderosa pine region of eastern Oregon was obtained from A. J. F. Brandstrom of the Pacific Northwest Forest and Range Experiment Station. This information from Brandstrom's unpublished records combined with data from R. R. Reynolds, of the Southern Forest Experiment Station, on loading with team and cross-haul and hauling with trucks as reported by him in the U. S. Forest Service Branch of Research Monthly Report for February 1937, pp. 22-23, makes it possible to treat the subject of loading more adequately and to compare the performance of the Speeder Loader with the other loading equipment. The car-loading, case D-3, will be discussed first.

49. Car-loading with a Barnhardt Loader (Case D-3).- The Barnhardt loader moved over the empty cars upon a "railroad" of its own formed by

1/ Made by the Speeder Machinery Company of Cedar Rapids, Iowa. The model of the machine here reported is TS40 mounted on a Diesel 40 Caterpillar tractor; for dirt-moving use it is rated as a 3/8 yard shovel.

rails fastened to the tops of the cars. The gaps in the rails from car to car were spanned by short rail sections put in place by the loading crew as the shift was made from one car to another. The propelling power for moves was furnished by a drum or winch upon the loader and was transmitted by reeling in a wire-rope towline fixed to one of the empty cars in the direction of travel. Because this type of loader requires a locomotive in almost constant attendance to keep it and the cars to be loaded abreast of the logs on the landing, a part of the hourly cost of the locomotive is included in the loader's hourly cost (table 15.) When manned by a skilled crew a loader of this type is most efficient; inspection of table 32 and figure 5 bears out this statement. The highest cost per M board feet (Doyle-Scribner) is for the logs of 12-inch trees - $0.32; for logs of 20-inch trees the cost per M board feet (Doyle-Scribner) is $0.07.

Figure 5, split into quarters like figures 2, 3 and 4, shows the Barnhardt car-loading as a broken line Inasmuch as car-loading by this system is so inexpensive no more attention will be paid to it in the present report.

50. Truck-loading with a Speeder Loader (case D-2).-In table 31 and figure 5 the performance of the Speeder Loader in loading short logs (averaging slightly over 16 feet in length) and in bunching and loading is shown. The costs shown are those for the loader alone, no cost for the trucks and trailers while loading is charged. This treatment of costs is of interest in comparing the loading costs of the Barnhardt car-loader with those of the Speeder Loader and more particularly to make an estimate of the costs of bunching logs in the woods by the Speeder Loader while the trucks are away. The difference between the rows in table 31 labelled "Bunching and loading" and "Loading only" or between the curves "Bunching and loading on trucks" and "Loading on trucks" in figure 5 gives an estimate of bunching cost in

terms of hours or money. As stated in the footnote of table 31 the estimate of bunching cost is based upon an average bunching distance of 41 feet for 78 percent of the logs, the rest of the logs were not moved.

It has been shown in table 33 that the cost of hooking and unhooking tree-length logs with arch-skidding tractors (meaning the assembly of the load preparatory to skidding and the disengaging of the load at the landing) is greater than the cost of loading the short logs from trees of the same sizes upon trucks and trailers with the Speeder Loader. For the purpose at hand a better comparison can be made. It is between the cost of hooking and unhooking for the arch-skidding tractors and the cost of bunching and loading for the Speeder Loader including the cost of the time involved for the truck and trailer, even though this comparison ignores the unloading cost.

Anticipating a part of the discussion in sections 52 and 53 we shall take the hourly cost of the Speeder Loader to be $2.51 and that of the truck and trailer to be $1.44. Assuming that the bunching of the logs is done in the absence of the truck the proper charge for bunching is the cost of the Speeder Loader's time; for loading, the charge is the cost of the time of the Speeder Loader and the truck and trailer. On this basis the cost of bunching and loading short logs from trees of specified diameters is as follows:

Tree-diameter class (Inches)	Cost per 100 cubic feet	Cost per M board feet (Doyle-Scribner)
12	$1.24	$3.64
16	.81	1.68
20	.61	1.06
24	.52	.80
28	.44	.64
32	.42	.55

The costs shown in the preceding table are certain of those of table 31 revised to include the cost of the truck and trailer time consumed while loading. Compared with the hooking and unhooking costs for the arch-skidding tractors in table 33 they bear closest resemblance to those of case A-1. On the basis of this comparison it appears as though there is a saving in the cost of hooking and unhooking with arch-skidding tractors over bunching and loading on trucks and trailers with a Speeder Loader. The difference in some instances is not great and the number of cases is probably too few and woods conditions too varied to permit a definite generalization. Comparison of the tractor-skidding costs with total truck-hauling costs is beyond the scope of the present report.

51. The truck-loading cases of figure 10.-Figure 10 shows the costs of loading trucks and trailers for 7 cases. The explanatory notes for figure 10 contain the essential information about the various pieces of loading equipment. Five of the cases are from eastern Oregon dealing with ponderosa pine, each of these pieces of equipment was a boom loader. One was a sled-mounted boom loader while the remaining 4 were converted power shovels. The 2 cases dealing with southern pine consisted of case D-2, the Speeder Loader previously described, and case OL-1 where a team cross-haul was used for loading the truck and trailer. The team cross-haul is the method usually employed for truck-loading in the South. The logs, ranked on the ground parallel to the truck and trailer, are rolled to their positions on the load by a parbuckle hitch powered by the team.

52. The hourly costs for loading equipment and truck and trailer.- The hourly costs for the loading equipment are shown only in the total in the notes for figure 10. These hourly costs have been prepared in a like manner to the other hourly costs of the present report. The wages used conform to the common wage base; that is, to the wages paid at Crossett for similar jobs.

It should be noted that the hourly cost of the Speeder Loader, case D-2, has been increased by about 10 percent over what it was in table 14, because the use of the common wage base rather than the wages actually paid in case D-2.

Two hourly costs for the truck and trailer have been prepared assuming a 4-mile haul from the woods to the landing. The one for the cross-haul loading system calls for 5 completed trips for the 8 hour day with a daily travel distance of 40 miles, the other for the mechanical loading systems calls for 6 completed trips with a daily travel distance of 48 miles. These hourly costs are $1.33 and $1.44 respectively. Of course, the number of trips per day varies because the loading time depends in part upon the size of logs handled. But for the sake of simplicity it was deemed advisable to use 2 hourly costs of the truck and trailer rather than an hourly cost which varied with each loading case presented and by the size of the logs handled within each case.

53. Comparison of truck-loading in figure 10.-Because the comparison of loading cost for the different cases involves the use of information dealing with 2 species of timber it was necessary to adjust for the difference in weight. Loading time in hours per 100 cubic feet in trees of different diameters (based upon the volumes of pine trees at Crossett) for the ponderosa pine cases from eastern Oregon was increased by the ratio which the weight per cubic foot of green loblolly pine, 52 pounds, bears to the weight per cubic foot of green ponderosa pine, 45 pounds. From the adjusted loading time in hours per 100 cubic feet in each tree-diameter class the time in hours per M board feet by the 3 log rules was found by application of the board foot-cubic foot ratios. The loading cost was obtained by use of the hourly costs shown in the notes of figure 10 where the charges for the truck and trailer are included in the total hourly cost.

The quarters of figure 10 present the same information of loading cost by tree-diameter for 4 units of measure of the logs; that is, per 100 cubic feet and per M board feet by 3 log rules. The usual downward trend in cost occurs as tree-diameter increases. For the range in tree-diameters from 14 to 24 inches 3 groups of loading systems might be made based on their similarity in cost. In the first group case OL-1 would stand alone, cases OL-6 and OL-2 would comprise the second group while the remaining 4 cases would make up the third group. As the size of the timber increases it is noteworthy that the loading cost of case OL-1 does not decrease so rapidly as with the remaining cases which are somewhat uniform in this respect. Both cases of the second group show high loading cost in the smaller diameter classes but decrease rapidly and join the third group in point of cost in larger diameters.

In the third group the costs are quite similar in trend, and fairly uniform in quantity for any point in range of tree-diameters shown. Case D-2, the Speeder Loader from Alabama, shows the highest costs in the third group, but the difference between the cases is slight. It should be noted, however, that case D-2 is the one representative among mechanical loaders which was actually operating under the conditions of southern logging. Whatever influences on cost existing with the other cases still remain except the difference in the weight of the timber. Insofar as the comparison of loading costs in figure 10 is a fair one, the loading cases from the South show up favorably with those from the ponderosa pine region.

Though the cross-haul loading costs are higher than for any of the other cases shown in figure 10, the system does not warrant disfavor on this score alone. The loading system is simple, the investment in equipment is limited to a team. The other systems while cheaper for sustained production call for skilled operators, and the investment for specialized

equipment is high. If logging is temporarily halted or ceases the team can be put to some other use while alternative uses for the mechanical loading equipment are not so readily found. If it is desirable to spread out the logging operation the cross-haul system has an advantage because of its lower output enabling fewer trucks to load from one location.[1] For example,

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1/ The hours required per unit of volume for loading are not shown in figure 10 because of the different hourly costs for the loading equipment. They may readily be found by dividing any loading cost by the hourly rate for the loading equipment involved.

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the time required to load 100 cubic feet of logs from 20-inch trees with the team cross-haul, case OL-1, is 0.30 hours or about 18 minutes while the corresponding time for the Speeder Loader, case D-2, is 0.09 hours or about 5½ minutes; the loading output of the team cross-haul is, therefore, less than 1/3 of the output of the Speeder Loader when operating with logs from 20-inch trees. The cost of loading logs from 20-inch trees with the Speeder Loader is $0.38 per 100 cubic feet contrasted with $0.65 per 100 cubic feet for the team cross-haul. The difference in loading cost is not nearly so great as the difference in time required because the hourly cost for the Speeder Loader is almost twice that of the team cross-haul.

For small truck logging operations, where few trucks are used and where little capital is available for the purchase of equipment, it is doubtful if the use of the team cross-haul for loading will ever be supplanted unless by another method using equally cheap equipment. However, for large operations using many trucks and trailers for hauling logs the savings in logging cost to be made through using a boom loader are material. There appears to be an opportunity to develop a loader with operating characteristics substantially the same as those of the Speeder Loader but cheaper in initial investment than the $5,600 which represents its cost. If the

use of a truck chassis rather than that of a tractor could be brought about for mounting the loader the first cost might be markedly reduced.

VIII. DAMAGE BY LOGGING TO THE REMAINING TREES OF THE TIMBER STAND

54. Logging damage cruise at Crossett.-According to the practice in use at Crossett for marking timber to cut, about one-half of the board-foot volume of pines more than 13 inches in diameter was designated for removal and the remainder was reserved for further growth. The hardwoods were not marked for cutting, they comprised a small percentage of the stand by volume and the supervisor of the cutting crews directed the cutting of those considered merchantable. Damage by logging to the trees of the reserve stand is a matter of great concern in a system of partial cutting where it is intended to return in the future to log some of the trees now being left. After the logging was completed in the tractor logging area at Crossett an examination was made of the damage to the timber left uncut.

The inventory of logging damage was made in a 20 percent strip cruise in June 1936, just after the tract was logged, and again in December 1936 when growth had ceased for the year. The damage from logging was from two sources: Damage from felling trees and damage from skidding. The damage from felling was manifested by broken branches and bark removal caused by falling trees colliding with the trees not included in the cut. In some instances the standing trees were broken off by the collision. Felling damage usually appeared in the upper half of the injured tree but it was frequently apparent in the long streaks of exposed wood extending through much of the tree-length. The damage from skidding usually appeared as patches of exposed wood in the lower 4 feet of the tree-trunk, sometimes the smaller trees were completely uprooted or broken off near the surface

of the ground. Skidding damage was due either to the tractor or to its load of logs. A summary of the results of the damage inventory is shown in table 35.

It will be noted that both felling and skidding injuries are the total of an item under "Injured but living, December 1936" and "Dead, December 1936." For the pine the felling injury is 12 percent compared to 7 percent for skidding injury. One of the reasons that both felling and skidding damage is about twice as great in the hardwoods as in the pines is because instructions were given the workmen to favor the pines. Almost all of the mortality for both felling and skidding injury in pines occurred in the 10-inch and smaller diameter classes.

It is a matter of conjecture as to whether deaths among the injured trees were confined to the 1936 growing season. It is possible that additional losses took place in 1937 and will occur in subsequent years. It is believed, however, that losses after 1936 will not be important.

The contrast is noteworthy between the high mortality due to felling injury and the low mortality due to skidding injury. A part of the difference is due to the greater amount of total destruction in the felling injury. Other reasons for the contrast appear to be the greater amount of bark removed in felling injury and the presumably greater resistance of injured trees to wounds close to the ground.

From observation of the conduct of the logging it would appear that some of the injury, both felling and skidding, could be avoided by better supervision. However, even injury of the extent shown is not a bar to the successful practice of a partial cutting system. The usual salvage cut for pulpwood after logging has taken place will utilize the small pines destroyed during logging as well as some of the material in the tops of sawlog trees. The injured pines which are likely not to survive may be

removed at the same time. Because the pulp mill at Crossett was not yet operating and because the pulpwood market at nearby mills was not good, the tractor logging area did not have a thorough salvage cut. Some of the small trees killed during logging were removed along with a few of the tops of sawlog trees but none of the injured trees still standing were cut on 240 acres of the 320-acre tract. On 80 acres some of these injured trees were removed; hence, the information for this area is excluded from table 35.

Approximately 33 percent of the logged area was traversed by the tractors in skidding. Part of this coverage of the area was represented by well-worn tractor roads but most of it consisted of the evidence of single trips or a few trips of the tractor either with or without logs.

IX. CONCLUSIONS

From the findings of the present report the following points are offered in conclusion:

1. The performance of the individual cases in tractor skidding varied considerably both in output and in cost. For similar equipment a part of the variation is due to difference in operating conditions, another part of the variation is due to differences in the efficiency of the operating crews. The lowest costs in skidding were encountered where the tractors had been in use 9 months or more.

2. All of the ground-skidding tractors with one exception showed costs which rose rapidly with increase of skidding distance. The rise in cost with increase in skidding distance was not so rapid for the tractors equipped with skidding pans or fair-lead arches for lessening the friction of the logs in the load. It appears that for distances of 1,000 feet or

more a tractor equipped with a skidding pan probably would skid logs at lower cost than a ground-skidding tractor or one equipped with a fair-lead arch.

3. The use of a relay system of skidding at Crossett, whereby the logs were concentrated by a ground-skidding tractor and later were skidded to the landing by an arch-skidding tractor, did not prove to be as cheap as a system under which the arch-skidding tractor bunched its own logs. The lowest costs of all the cases skidding more than 1,000 feet were obtained, however, under a modified relay system at Jackson, Alabama, where a team and teamster helped to concentrate the load prior to skidding to the landing.

4. From the results of tractor-skidding at Crossett in the spring of 1936 no statement can be made with respect to tractor performance in the wet spring weather usually encountered there. The spring of 1936 was abnormally dry and no weather wet enough to hamper logging occurred during the 70-day work period.

5. The performance of the more efficient tractors in the South recorded for the present report exceeded that of tractors skidding in other parts of the country for which information is available. In the comparison allowance was made for difference in weight of the timber and differences in wages and other items of expense.

6. A comparison was made of the costs of loading trucks and trailers by a Speeder Loader and a team cross-haul in the South with the costs of loading trucks and trailers in the ponderosa pine region using 5 mechanical loaders. When the adjustments were made to equalize wages and other items of expense and when allowance was made for the difference in the weight of timber, the loading costs of the Speeder Loader were among the lowest while the costs of the team cross-haul were among the highest of

the 7 cases compared.

7. An inventory of 240 acres of the Crossett tractor logging area when logging ceased in June 1936 and again in December 1936 showed that about 81 percent of the pines 5 inches in diameter or larger suffered no logging injury. Twelve percent of the pines were injured by felling and about one half of these were destroyed outright or died before December 1936. Skidding accounted for 7 percent of the number of pines injured and only one seventh of these were dead in December 1936.

TABLES AND FIGURES

TABLES

FIGURES

TABLES

Table 1. -- Some tractor specifications [1]

	Caterpillar tractors					McCor.-Deering Diesel 40
	RD7	Diesel 50	RD6	RD4	Gasoline 30	
Drawbar horse power	61	53	45	35	35	45
Shipping weight (tons) [2]	11.6	10.6	8.4	5.3	5.1	6.5
Speed in different gears (mi.p.hr.)						
First	1.6	1.6	1.7	1.7	1.7	1.7
Second	2.4	2.4	2.5	2.4	2.4	2.2
Third	3.4	3.4	3.9	3.0	3.0	2.7
Fourth	4.7	4.7	4.6	3.7	3.7	3.2
Fifth	-	-	-	5.4	5.4	4.0
Fuel consumption (gal.p.hr.) [3]	3.1	-	2.0	1.2	3.7	-
Delivered price at Crossett [2]	$6,445	-	$4,545	$3,340	$2,940	-

[1] From Track-type tractors, comparative specifications, Caterpillar Tractor Co., except as noted in table.

[2] Including winch.

[3] From fuel records at Crossett.

Table 2. -- Volumes for trees[1] of specified diameters in cubic feet and board feet by 3 log rules

D.b.h.[2]	Basis trees[3]	Sawlog length	Logs per tree	Volume of sawlog section	Doyle-Scribner Bd.ft. per cu.ft.	Doyle-Scribner Volume	Scrib. Dec. C Bd.ft. per cu.ft.	Scrib. Dec. C Volume	Int. scale (¼-in.) Bd.ft. per cu.ft.	Int. scale (¼-in.) Volume
(1)		(3)		(5)		(7)		(9)		(11)
(Inches)	Number	Feet	Number	Cu.ft.	Number	Bd.ft.	Number	Bd.ft.	Number	Bd.ft.
10				10.2	2.73	28	4.86	50	6.22	63
12	182	27	1.90	16.0	3.46	55	5.13	82	6.45	103
14	689	30	1.96	23.1	4.15	96	5.43	125	6.65	154
16	926	32	2.03	31.5	4.80	151	5.72	180	6.82	215
18	858	33	2.10	41.0	5.31	218	5.97	245	6.97	286
20	651	35	2.17	51.0	5.80	296	6.23	318	7.09	362
22	453	36	2.23	63.0	6.20	391	6.47	408	7.22	455
24	279	36	2.30	77.0	6.53	503	6.71	517	7.33	564
26	168	37	2.36	92.0	6.82	627	6.92	637	7.37	678
28	102	39	2.43	111.0	7.06	784	7.08	786	7.45	827
30	66	40	2.50	133.0	7.25	964	7.23	962	7.49	996
32	35	41	2.57	157.0	7.42	1,165	7.33	1,151	7.53	1,182
34	10	43	2.63	181.0	7.54	1,365	7.43	1,345	7.56	1,368

1/ Shortleaf and loblolly pines. The number of board feet per cubic foot are for loblolly pine.

2/ Diameter breast high; that is, diameter of the tree outside the bark 4½ feet above the ground.

3/ For Columns 3 and 5 only.

Table 3. -- Summary [1/] of estimated hourly cost involved in operating different logging equipment.

Equipment and operator	Case number	Men in crew	Direct labor cost		Other direct cost		Ownership cost		Total cost	Adjusted total cost [2/]
		Number		Percent		Percent		Percent		
Arch-skidding tractors										
RD7; C.T.Co.(4)[3/]	A-1,A-2	3	$0.981	25.1	$1.868	47.8	$1.054	27.1	$3.903	
Diesel 50; B-S.Co.(5)	A-3	3	.775	19.7	1.948	49.5	1.215	30.8	3.938	$4.144
RD6; C.T.Co.(6)	A-4	3	.981	30.0	1.536	47.0	.752	23.0	3.269	
Pan-skidding tractors										
RD7; B-S.Co.(7)	B-1	3	.775	23.8	1.633	50.1	.851	26.1	3.259	3.465
RD6; J.L.Co.(8)	B-2	3	.688	27.3	1.259	50.0	.570	22.7	2.517	2.911
Ground-skidding tractors										
RD6; C.T.Co.(9)	C-1	2	.697	30.2	1.088	47.1	.525	22.7	2.310	
M.D.40[4/]; P.R.V.I.Co.(10)	C-2	2 2/5	.599	26.6	1.216	54.0	.438	19.4	2.253	2.465
RD4; C.T.Co.(11)	C-3,C-4	2	.697	35.9	.867	44.6	.378	19.5	1.942	
Gas 30; do. (12)	C-5	2	.697	26.2	1.632	61.3	.332	12.5	2.661	
Other equipment										
Team; C.L.Co.(13)	D-1	1	.385	47.0	.390	47.5	.045	5.5	.820	
Loader; W.T.S.I.Co.(14)	D-2	3	.702	31.4	1.086	48.6	.447	20.0	2.235	2.514
Loader; C.L.Co.(15)	D-3	5 (5/)	1.904	65.1	.790	27.0	.230	7.9	2.924	

1/ Of tables 4 to 15.

2/ Adjusted to a common wage base; the rates used for wages by Caterpillar Tractor Co. and Crossett Lumber Co. are taken for the common base.

3/ Figures in parentheses refer to tables from which these data are taken.

4/ McCormick-Deering Diesel 40 without winch; all other tractors listed were built by the Caterpillar Tractor Co. and were winch-equipped.

5/ Loading crew of 5 men; the locomotive crew of 2 was also required.

Table 3a. -- Basis of cable and rigging charges in hourly cost tables - cost by type of use and size of tractors

WINCH LINES

Company	Case No.	Wire rope (or hook or tongs)			Cost[1]		Remarks
		Diameter	Length	Life (or record period)	Per unit (or for record period)	Per hour	
		Inches	Feet	Hours			
Large tractors, arch-skidding							
Caterpillar Tractor Co.	A-1, A-2	7/8	(80)	(446)	($ 79)	$.177	Record for 446 hours
Brooks-Scanlon Corp.	A-3	3/4	250	1000	55	.055	Foreman's statement
Large tractors, pan-skidding							
Brooks-Scanlon Corp.	B-1	11/16	700	700	126	.180	Foreman's statement
Large tractors, ground-skidding							
Patterson-McInnes	---	3/4	100	150	22	.147	RD 7 at Gulf Hammock, Fla., foreman's statement
Medium tractors, arch-skidding							
Caterpillar Tractor Co.	A-4	3/4	(80)	(386)	(74)	.192	Record for 386 hours
Medium tractors, ground-skidding							
Caterpillar Tractor Co.	C-1	3/4	(80)	(386)	(74)	.192	In records, winch line cost not separated for cases A-4 and C-1; same tractor in both cases
Small tractors, ground-skidding							
Caterpillar Tractor Co.	C-3, C-4	5/8	(80)	(111)	(10)	.090	Record for 111 hours
Caterpillar Tractor Co.	C-5	5/8	(80)	(108)	(27)	.250	Record for 108 hours

1/ Includes installation labor for splicing and babbitting, where needed.

Table 3a. -- Continued.

CHOKER WIRE

Company	Case No.	Wire rope (or hook or tongs) Diameter	Length	Life (or record period)	Cost[1] Per unit (or for record period)	Per hour	Remarks
		Inches	Feet	Hours			
Large tractors, arch-skidding Caterpillar Tractor Co.	A-1, A-2	5/8-7/8	(15-17)	(446)	($129)	$0.288	Record for 446 hours
Large tractors, ground skidding Patterson-McInnes	---	3/4	17	110[2]	6	.055	RD 7, Gulf Hammock, Fla. foreman's statement
Medium tractors, arch-skidding Caterpillar Tractor Co.	A-4			(210)	(48)	.230	Record for 210 hours
Medium tractors, ground-skidding Pearl River Valley Lbr. Co.	C-2	3/4	15	180[3]	5	.028	Foreman's statement
CHOKER AND BUTT HOOKS							
Large tractors, arch-skidding Caterpillar Tractor Co.	A-1, A-2			(446)	(105)	.236	Record for 446 hours
Medium tractors, arch-skidding Caterpillar Tractor Co.	A-4			(210)	(34)	.162	Record for 210 hours
TONGS							
Medium tractors, ground-skidding Caterpillar Tractor Co.	C-1			(176)	(10)	.057	Record for 176 hours
Small tractors, ground-skidding Caterpillar Tractor Co.	C-3, C-4			(111)	(11)	.100	Record for 111 hours
Caterpillar Tractor Co.	C-5			(108)	(10)	.093	Record for 108 hours

1/ Includes installation labor for splicing and babbitting, where needed.

2/ Four chokers in use, therefore choker life is shown as 110 hours rather than 440 (the period a choker lasted before breaking).

3/ Six chokers in use, therefore choker life is shown as 180 hours rather than 1080 (the period a choker lasted before breaking).

Table 4. -- Estimated hourly cost involved in operating winch-equipped RD7 Caterpillar tractor with 10-ton arch - Caterpillar Tractor Company at Crossett. (Case A-1, A-2)

Initial cost $9,210

Average investment $5,725

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Driver	$0.400		10.2	
Helpers, 2 at 0.27½	.550		14.1	
Insurance (industrial and employment) 3-1/3 percent	.031		.8	
Total direct labor cost		$0.981		25.1
2. Other direct cost				
Fuel 3.1 gals. at $0.06	$0.188		4.8	
Lubricating oil .086 gals. at 0.60	.052		1.3	
Grease .60 lbs at 0.125	.075		1.9	
Starting-engine gasoline .07 gals at 0.175	.003		.1	
Service labor	.057		1.5	
Cable and rigging	.701		17.9	
Repair parts) Repair labor)	.596 1/		15.3	
Transportation of crew	.063		1.6	
Supervision	.133		3.4	
Total other direct cost		1.868		47.8
B. Ownership cost				
Depreciation (12,000 hours)	$0.767		19.7	
Interest, taxes, fire insurance and uninsured risks	.287		7.4	
Total ownership cost		1.054		27.1
GRAND TOTAL		$3.903		100.0

Based on 438 hours of operation.

1/ Actual cost of repair parts and labor during period of operation $0.01 per hour.

Table 5. -- Estimated hourly cost involved in operating winch-equipped Diesel 50 Caterpillar tractor with 10-ton arch - Brooks-Scanlon Corporation (Case A-3)

Initial cost $9,210
Average investment $5,526

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Driver at $0.32	$0.320		8.1	
Hooker at $0.23	.230		5.9	
Helper at $0.20	.200		5.1	
Industrial and employment insurance 3.3 percent of above	.025		.6	
Total direct labor cost		$0.775		19.7
2. Other direct cost				
Fuel 1.8 gal. at $0.06	$0.110		2.8	
Supplies 1/	1.242		31.5	
Service labor	.050		1.3	
Repair labor	.333		8.5	
Transportation of crew	.063		1.6	
Supervision	.150		3.8	
Total other direct cost		$1.948		49.5
B. Ownership cost				
Depreciation (10,000 hrs.)	$0.921		23.4	
Interest, taxes, fire insurance and uninsured risks 10% of average investment	.294		7.4	
Total ownership cost		$1.215		30.8
GRAND TOTAL		$3.938		100.0

If wages were computed on the common base, total hourly cost would be $4.144.

1/ Includes repair parts, lubricating oil, grease and rigging - 1935 average for tractor only, with 25 percent added to care for arch.

Table 6. -- Estimated hourly cost involved in operating winch-equipped RD6 Caterpillar tractor with 6-ton arch - Caterpillar Tractor Company at Crossett. (Case A-4)

Initial cost $6,565

Average investment $4,111

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Driver	$0.400		12.2	
Helpers, 2 at $0.27½	.550		16.9	
Insurance (industrial and employment) 3-1/3 percent	.031		.9	
Total direct labor cost		0.981		30.0
2. Other direct cost				
Fuel 1.99 gals. at $0.06	0.119		3.6	
Lubricating oil .080 gals. at $.60	.048		1.5	
Grease 48 lbs. at $.125	.060		1.8	
Starting-engine gasoline .025 gals. at $.175	.004		.1	
Service labor	.057		1.7	
Cable and rigging	.584		18.0	
Repair parts) Repair labor)	.468 1/		14.3	
Transportation of crew	.063		1.9	
Supervision	.133		4.1	
Total other direct cost		1.536		47.0
B. Ownership cost				
Depreciation (12,000 hours)	$0.546		16.7	
Interest, taxes, fire insurance, and uninsured risks	.206		6.3	
Total ownership cost		0.752		23.0
GRAND TOTAL		$3.269		100.0

Based on 210 hours of operation.

1/ Actual cost of repair parts and labor during period of operation $0.08 per hour.

Table 7. -- Estimated hourly cost involved in operating winch-equipped RD7 Caterpillar tractor with skidding pan - Brooks-Scanlon Corporation (Case B-1)

Initial cost $6,445
Average investment $3,867

A. Current operating cost	Cost per hour		Percent of total	
1. Direct labor cost				
Driver at $0.32	$0.320		9.8	
Hooker at $0.23	.230		7.1	
Helper at $0.20	.200		6.1	
Industrial and employment insurance 3.3 percent of above	.025		.8	
Total direct labor cost		$0.775		23.8
2. Other direct cost				
Fuel 1.8 gals. at $0.06	0.110		3.4	
Supplies 1/	.994		30.5	
Service labor	.050		1.5	
Repair labor	.266		8.2	
Transportation of crew	.063		1.9	
Supervision - 1/3 of hd. operator at $0.45	.150		4.6	
Total other direct cost		1.633		50.1
B. Ownership cost				
Depreciation (10,000 hours)	0.645		19.8	
Interest, taxes, fire insurance and uninsured risks, 10 percent of average investment	.206		6.3	
Total ownership cost		.851		26.1
GRAND TOTAL		$3.259		100.0

If wages were computed on the common base, total hourly cost would be $3.465.

1/ Includes repair parts, lubricating oil, grease and rigging - 1935 average.

Table 8. -- Estimated hourly cost involved in operating winch-equipped RD6 Caterpillar tractor with skidding pan and mule team - Jackson Lumber Company (Case B-2)

Initial cost of tractor $4,545
Average investment 2,933

	Tractor		Mule team	
A. Current operating cost	Cost per hour	Percent of total	Cost per hour	Percent of total
1. Direct labor cost				
Driver or teamster[1/]	$0.284	14.6	$0.204	35.4
Helper[1/]	.178	9.2		
Ind. and unemployment insurance (3-1/3 percent of above)	.015	.8	.007	1.2
Total direct labor cost	.477	24.6	.211	36.6
2. Other direct cost				
Fuel, lubricating oil, grease and starting-engine gasoline[2/]	.159	8.2		
Cable and rigging (estimated)	.125	6.4		
Repair parts[3/]	.419	21.6		
Repair labor[3/]	.040	2.1		
Transportation of crew	.063	3.3		
Feed			.250	43.4
Harness upkeep			.020	3.5
Supervision	.133	6.8	.050	8.7
Total other direct cost	.939	48.4	.320	55.6
B. Ownership cost				
Depreciation	.378	19.4	.030	5.2
Taxes, interest, uninsured risks	.147	7.6	.015	2.6
Total ownership cost	.525	27.0	.045	7.8
Total tractor cost	1.941	100.0		
Total team cost	.576		.576	100.0
Total cost for tractor and team	2.517			

If wages were computed on the common base, total hourly cost would be $2.911.

1/ From contract earnings over period, February to July, 1936.
2/ Cost over same period.
3/ Cost of parts and labor for 10-month period ending Sept. 30, 1936.

Table 9. -- Estimated hourly cost involved in operating winch-equipped RD6 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-1)

Initial cost $4,545

Average investment $2,933

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Driver	$0.400		17.3	
Helper	.275		11.9	
Insurance (industrial and employment) 3-1/3% of above	.022		1.0	
Total direct labor cost		$0.697		30.2
2. Other direct cost				
Fuel 1.92 gals. at $0.06	0.115		5.0	
Lubricating oil .078 gals. at $.60	.047		2.0	
Grease .32 lbs. at .125	.040		1.7	
Starting-engine gasoline .027 gals. at .175	.005		.2	
Service labor	.069		3.0	
Cable and rigging	.249		10.8	
Repair parts) Repair labor)	.367 1/		15.9	
Transportation of crew	.063		2.7	
Supervision	.133		5.8	
Total other direct cost		1.088		47.1
B. Ownership cost				
Depreciation (12,000 hours)	0.378		16.3	
Interest, taxes, fire insurance, and uninsured risks	.147		6.4	
Total ownership cost		0.525		22.7
GRAND TOTAL		$2.310		100.0

Based on 170 hours of operation.

1/ Actual cost of repair parts and labor during period of operation $0.04 per hour.

Table 10. -- Estimated hourly cost involved in operating McCormick-Deering Diesel 40 tractor[1/] - Pearl River Valley Lumber Company (Case C-2)

Initial cost $3,900
Average investment $2,274

A. Current operating cost	Cost per hour		Percent of total	
1. Direct labor cost				
1 driver at $0.30	$0.300		13.3	
1 helper at $ .20	.200		8.9	
2/5 unhooker at $.20	.080		3.6	
Industrial and employment insurance - 3.3 percent of above	.019		.8	
Total direct labor cost		$0.599		26.6
2. Other direct cost				
Fuel 15 gallons at $.06	$0.090		4.0	
Lubricating oil 0.15 gal. at .60	.090		4.0	
Grease 0.8 lbs. at $0.125	.100		4.4	
1/5 oil and water boy $0.20	.040		1.8	
Service labor	.050		2.2	
Repairs - parts and labor (estimated)	.600		26.7	
Rigging	.050		2.2	
Crew transportation	.063		2.8	
Supervision	.133		5.9	
Total other direct cost		$1.216		54.0
B. Ownership cost				
Depreciation (12,000 hours)	$0.325		14.4	
Interest, taxes, fire insurance and uninsured risks 10% of ave. investment	.113		5.0	
Total ownership cost		$0.438		19.4
GRAND TOTAL		$2.253		100.0

If wages were computed on the common base, total hourly cost would be $2.465.

1/ Without winch.

Table 11. -- Estimated hourly cost involved in operating winch-equipped RD 4 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-3, C-4)

Initial cost $3,340

Average investment $1,990

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Driver	$0.400		20.6	
Helper	.275		14.2	
Insurance (industrial and employment) 3-1/3% of above	.022		1.1	
Total direct labor cost		$0.697		35.9
2. Other direct cost				
Fuel 1.24 gals. at $0.06	0.074		3.8	
Lubricating oil .042 gals. at .60	.025		1.3	
Grease .28 lbs. at .125	.035		1.8	
Starting-engine gasoline .02 gals. at .175	.003		.2	
Service labor	.048		2.5	
Cable and rigging	.190		9.8	
Repair parts) Repair labor)	.296 1/		15.2	
Transportation of crew	.063		3.2	
Supervision	.133		6.8	
Total other direct cost		.867		44.6
B. Ownership cost				
Depreciation (12,000 hours)	$0.278		14.4	
Interest, taxes, fire insurance and uninsured risks	.100		5.1	
Total ownership cost		.378		19.5
GRAND TOTAL		$1.942		100.0

Based on 110 hours of operation.

1/ Actual cost of repair parts and labor during period of operation $0.148 per hour.

Table 12. -- Estimated hourly cost involved in operating winch-equipped Gas 30 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-5)

Initial cost $2,940

Average investment $1,757

A. Current operating cost	Cost per hour		Percent of total	
1. Direct labor cost				
Driver	$0.400		15.1	
Helper	.275		10.3	
Insurance (industrial and employment) 3-1/3% of above	.022		.8	
Total direct labor cost		$0.697		26.2
2. Other direct cost				
Fuel 3.68 gals. at $0.175	$0.644		24.1	
Lubricating oil .06 gals. at .60	.036		1.4	
Grease .28 lbs. at .125	.035		1.3	
Service labor	.082		3.1	
Cable and rigging	.343		12.9	
Repair parts) Repair labor)	.296 1/		11.1	
Transportation of crew	.063		2.4	
Supervision	.133		5.0	
Total other direct cost		1.632		61.3
B. Ownership cost				
Depreciation	$0.244		9.2	
Interest, taxes, fire insurance and uninsured risks	.088		3.3	
Total ownership cost		.332		12.5
GRAND TOTAL		$2.661		100.0

Based on 105 hours of operation.

1/ Actual cost of repair parts and labor during period of operation $0.063 per hour.

Table 13. -- Estimated hourly cost involved in operating 2-horse team with bummer - Crossett Lumber Company (Case D-1)

	Cost per hour		Percent of total	
A. Current operating cost				
1. Direct labor cost				
Teamster 1/	$0.373		45.5	
Industrial and unemployment insurance (3-1/3% of above)	.012		1.5	
Total direct labor cost		$0.385		47.0
2. Other direct cost				
Feed	$0.250		30.5	
Service labor	.050		6.1	
Harness and bummer upkeep	.020		2.4	
Supervision	.050		6.1	
Transportation of crew	.020		2.4	
Total other direct cost		.390		47.5
B. Ownership cost				
Depreciation of team	$0.030		3.7	
Taxes, insurance, uninsured risks	.015		1.8	
Total ownership cost		.045		5.5
GRAND TOTAL		$0.820		100.0

1/ Wage rate is based on the earnings of 2 teamsters skidding in dry weather by contract; $79 was earned in 212 hours of work over a period of one-half month.

Table 14. -- Estimated hourly cost involved in operating "Speeder Loader" - W. T. Smith Lumber Company (Case D-2)

Initial cost $5,600
Average investment $3,150

A. Current operating cost	Cost per hour		Percent of total	
1. Direct labor cost				
Loaderman at $0.32	$0.320		14.3	
Top loader at $0.18	.180		8.1	
Tong hooker at $0.18	.180		8.1	
Industrial and employment insurance - 3.3 percent of above	.022		.9	
Total direct labor		$0.702		31.4
2. Other direct cost				
Fuel 1.5 gals. at $0.06	0.090		4.0	
Lubricating oil 0.08 gals. at $0.60	.048		2.2	
Grease 0.5 lb. at $0.125	.063		2.8	
Starting engine gasoline 0.03 gal. at .18	.005		.2	
Service labor	.057		2.6	
Cable and rigging	.060		2.7	
Repair parts) Repair labor)	.570		25.5	
Transportation of crew	.063		2.8	
Supervision	.130		5.8	
Total other direct cost		$1.086		48.6
B. Ownership cost				
Depreciation (16,000 hours)	0.287		12.8	
Interest, taxes, fire insurance and uninsured risks - 10% of average investment	.160		7.2	
Total ownership cost		.447		20.0
GRAND TOTAL		$2.235		100.0

If wages were computed on the common base, total hourly cost would be $2.514.

Table 15. -- Estimated hourly cost involved in operating Barnhardt car-top loader (and locomotive while loading) - Crossett Lumber Company (Case D-3)

Present value of Barnhardt loader $3,500
" " " Baldwin locomotive $2,500

A. Current operating costs	Cost per hour		Percent of total	
1. Direct labor cost 1/				
1 Loaderman at $0.50	$0.50		17.1	
1 Top loader at $.29	.29		9.9	
3 Tong hookers at $.275 each	.825		28.2	
1/3 Locomotive engineer at $.40	.133		4.6	
1/3 " fireman at $.285	.095		3.2	
Industrial and employment insurance 3.3 percent of above	.061		2.1	
Total direct labor cost		$1.904		65.1
2. Other direct cost				
Fuel and oil for loader -				
Fuel oil 6 gals. at $0.024	$0.140		4.8	
Oils and waste	neg.			
Fuel and oil for locomotive -				
Fuel oil 1/3 of 40 gals. at $0.024	0.320		11.0	
Oils and waste	neg.			
Loading line	0.080		2.7	
Repairs-labor and supplies	.200		6.8	
Supervision	.050		1.7	
Total other direct cost		0.790		27.0
B. Ownership cost				
Depreciation	$0.100		3.4	
Interest on present value at 6%	.100		3.4	
Fire insurance and taxes at 2¼%	.030		1.1	
Total ownership cost		0.230		7.9
GRAND TOTAL		$2.924		100.0

1/ Includes service labor - greasing, fueling and firing up.

Table 16. -- Summary of basic logging information.

Equipment and operator	Case no.	Type of haul 1/	Elapsed time	Trips made	Logs 2/ skidded	Total volume 3/	Ave. vol. per trip	Ave. skid. dist.	Ave. time per 100 cu.ft.	Ave. time per 100 cu.ft. from table 4/
			Hours	No.	No.	Cu.ft.	Cu.ft.	Feet	Hours	Hours
Arch-skidding										
RD7; C.T.Co.	A-1	2	241.72	187	1,440	63,603	340	5,634	0.38	0.38
do do	A-2	3	167.06	110	859	36,616	333	9,241	0.46	0.44
Diesel 50; B-S Co.	A-3	2	77.85	100	877	26,710	267	2,415	0.29	0.30
RD6; C.T.Co.	A-4	2	148.96	172	931	40,882	238	2,853	0.36	0.37
do do	-	3	45.26	34	196	6,113	179	8,468	0.74	(5/)
Pan-skidding										
RD7; B-S Co.	B-1	2	56.20	82	536	16,835	205	2,677	0.33	0.32
RD6; J.L.Co.	B-2	2	52.43	78	654	15,295	196	3,655	0.34	0.34
Ground-skidding										
RD6; C.T.Co.	C-1	2	146.25	643	982	64,884	101	552	0.23	0.23
M.D.40; P.R.V.L.Co.	C-2	2	57.58	348	1,268	30,185	87	353	0.19	0.19
RD4; C.T.Co.	C-3	2	92.34	403	564	28,152	70	612	0.33	0.34
do do	C-4	1	14.78	178	242	6,557	37	144	0.23	0.24
Gas 30; do	C-5	1	77.41	614	694	31,617	51	271	0.24	0.24
Other										
Team; C.L.Co.	D-1	2	14.76	131	131	6,088	46	214	0.24	0.25
Loader; W.T.S.L.Co.	D-2	-	28.06		564	15,190	27	41	0.18	0.16

1/ Item 1 signifies skidding from stump to bunching point; item 2, skidding from stump to railroad; item 3, skidding from bunching point to railroad.

2/ Logs were tree-lengths, or practically so, with 3 exceptions. The maximum log-length at Pearl River Valley Lumber Co. was about 40 feet; the team skidding at Crossett Lumber Co. and truck-loading at W.T.Smith Lumber Co. was done in short logs - maximum length about 24 feet and average length somewhat over 16 feet.

3/ These quantities do not represent the actual volume at Crossett (for Caterpillar Tractor Co.) because the volume of the hardwood logs was increased by 23 percent to put them on an equal weight basis with pine logs. Hardwood logs over the whole Crossett experimental area were 11.9 percent of the total by volume. In the other localities the volumes are correct - no hardwoods were handled.

4/ Values from interpolation of respective estimates of time by specified tree-diameters and distances, tables 19 to 31.

5/ Data were too few for detailed analysis.

Table 17. -- Summary of classification of elapsed time of working day - by log cubic foot

Equipment and operator	Case no.	Type of haul 1/	Travel time to woods (empty)	Travel time to landing (loaded)	Hook and unhook time	Total effective working time	All delays 2/	Total elapsed time 3/	delay elapsed time
			Hours						Percent
Arch-skidding									
RD7; C.T.Co.	A-1	2	50.00	93.33	84.54	227.87	13.85	241.72	5.7
RD7; C.T.Co.	A-2	3	46.13	81.69	28.87	156.69	10.37	167.06	6.2
Diesel 50; B-S Co.	A-3	2	14.23	30.94	26.59	71.76	6.09	77.85	7.8
RD6; C.T.Co.	A-4	2	27.63	49.51	46.71	123.71	25.25	148.96	17.0
RD6; C.T.Co.	-	3	13.34	22.65	6.36	42.35	2.91	45.26	6.4
Pan-skidding									
RD7; B-S Co.	B-1	2	11.23	24.05	15.95	51.23	4.97	56.20	8.8
RD6; J.L.Co.	B-2	2	11.40	23.85	12.69	47.94	4.49	52.43	8.6
Ground skidding									
RD6; C.T.Co.	C-1	2	31.82	43.92	31.14	106.88	39.37	146.25	26.9
M.D.40; P.R.V.L.Co.	C-2	2	10.86	14.46	21.80	47.12	10.46	57.58	18.2
RD4; C.T.Co.	C-3	2	18.03	33.17	13.28	64.48	27.86	92.34	30.2
RD4; C.T.Co.	C-4	1	4.22	3.38	4.37	11.89	2.89	14.78	19.6
Gas 30; C.T.Co.	C-5	1	17.74	21.09	17.15	55.98	21.43	77.41	27.7
Other									
Team; C.L.Co.	D-1	2	3.04	3.20	3.91	10.15	4.61	14.76	31.2
Loader; W.T.S.L.Co.	D-2	-		7.69 (4/)	6.76 (4/)	14.55	13.51	28.06	48.1

1/ Item 1 signifies skidding from stump to bunching point; item 2, skidding from stump to railroad; item 3, skidding from bunching point to railroad.

2/ Time in working day not classified under head of actual working time. Delays consist of time lost due to machine or rigging trouble, rests etc.

3/ Time from start to end of the day, excluding lunch hour.

4/ Skidding and loading respectively.

Table 18. -- Hypothetical[1] load composition for specified tree-diameters in cubic foot and board foot volume

Equipment and operator	Case no.	12-inch trees: Trees	12-inch trees: Cu.ft. volume	12-inch trees: Doyle-Scribner volume	12-inch trees: Scribner Dec.C volume	12-inch trees: Int. volume	16-inch trees: Trees	16-inch trees: Cu.ft. volume	16-inch trees: Doyle-Scribner volume	16-inch trees: Scribner Dec.C volume	16-inch trees: Int. volume
		Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.	Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.
Arch-skidding tractors											
RD7; C.T.Co.	A-1	12.20	195.2	675	1,001	1,259	9.9	311.8	1,497	1,783	2,126
do do	A-2	11.00	176.0	609	903	1,135	9.3	293.0	1,406	1,676	1,998
D.50[2]; B-S Co.	A-3	11.10	177.6	614	911	1,146	8.5	267.8	1,235	1,532	1,826
RD6; C.T.Co.	A-4	11.40	182.4	631	936	1,176	7.0	220.5	1,038	1,261	1,504
Pan-skidding tractors											
RD7; B-S Co.	B-1	9.50	152.0	526	780	980	6.5	204.8	933	1,171	1,397
RD6; J.L.Co.	B-2	9.90	158.4	548	813	1,022	7.2	226.8	1,039	1,297	1,547
Ground-skidding tractors											
RD6; C.T.Co.	C-1	1.96	31.4	109	161	202	1.81	57.0	274	326	389
M.D.40[3]; P.R.L.Co.	C-2	4.13	66.1	229	339	426	3.37	106.2	510	607	724
RD4; C.T.Co.	C-3	1.92	30.7	106	158	198	1.64	51.7	248	296	353
do do	C-4	1.54	24.6	85	126	159	1.30	41.0	197	235	280
Gas 30; do	C-5	1.43	22.9	79	118	148	1.23	38.7	186	221	264

1/ This information is derived from computations showing share of the load chargeable to logs of given volume. These quantities are useful for comparison of relative use of equipment; they do not necessarily mean that this performance would occur in practice if trees of each size were hauled separately.

2/ Caterpillar Diesel 50.

3/ McCormick Deering Diesel 40.

Table 18. -- Continued.

Equipment and operator	Case no.	20-inch trees: Trees	20-inch trees: Cu.ft. volume	20-inch trees: Doyle-Scribner volume	20-inch trees: Scribner Dec.C volume	20-inch trees: Int. volume	24-inch trees: Trees	24-inch trees: Cu.ft. volume	24-inch trees: Doyle-Scribner volume	24-inch trees: Scribner Dec.C volume	24-inch trees: Int. volume
		Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.	Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.
Arch-skidding tractors											
RD7; C.T.Co.	A-1	7.60	387.6	2,248	2,415	2,748	5.60	431.2	2,816	2,893	3,161
do do	A-2	7.60	387.6	2,248	2,415	2,748	6.00	462.0	3,017	3,100	3,386
D.50 2/; B-S Co.	A-3	6.70	341.7	1,982	2,129	2,423	5.20	400.4	2,615	2,687	2,935
RD6; C.T.Co.	A-4	4.81	245.3	1,423	1,528	1,739	3.36	258.7	1,689	1,736	1,896
Pan-skidding tractors											
RD7; B-S Co.	B-1	4.67	238.2	1,382	1,484	1,689	3.38	260.3	1,700	1,747	1,908
RD6; J.L.Co.	B-2	5.50	280.5	1,627	1,748	1,989	4.10	315.7	2,062	2,118	2,314
Ground-skidding tractors											
RD6; C.T.Co.	C-1	1.64	83.6	485	521	593	1.46	112.4	734	754	824
M.D.40 3/; P.R.L.Co.	C-2	2.61	133.1	772	829	944	1.91	147.1	961	987	1,078
RD4; C.T.Co.	C-3	1.37	69.9	405	435	496	1.14	87.8	573	589	644
do do	C-4	1.06	54.1	314	337	384	1.00	77.0	503	517	564
Gas 30; do	C-5	1.08	55.1	320	343	391	1.00	77.0	503	517	564

2/ Caterpillar Diesel 50.

3/ McCormick Deering Diesel 40.

Table 18. -- Continued.

Equipment and operator	Case no.	28-inch trees					32-inch trees				
		Trees	Cu.ft. volume	Doyle-Scribner volume	Scribner Dec.C volume	Int. volume	Trees	Cu.ft. volume	Doyle-Scribner volume	Scribner Dec.C volume	Int. volume
		Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.	Number	Cu.ft.	Bd.ft.	Bd.ft.	Bd.ft.
Arch-skidding tractors											
RD7; C.T.Co.	A-1	3.79	420.7	2,970	2,979	3,134	2.54	398.8	2,959	2,923	3,003
do do	A-2	4.39	487.3	3,440	3,450	3,630	3.04	477.3	3,542	3,499	3,594
D.50 2/; B-S Co.	A-3	3.95	438.4	3,095	3,104	3,266					
RD6; C.T.Co.	A-4	2.40	266.4	1,881	1,886	1,985	1.74	273.2	2,027	2,003	2,057
Pan-skidding tractors											
RD7; B-S Co.	B-1										
RD6; J.L.Co.	B-2										
Ground-skidding tractors											
RD6; C.T.Co.	C-1	1.28	142.1	1,003	1,006	1,059	1.09	171.1	1,270	1,254	1,288
M.D.40 3/; P.R.L.Co.	C-2										
RD4; C.T.Co.	C-3	1.00	111.0	784	786	827	1.00	157.0	1,165	1,151	1,182
do do	C-4	1.00	111.0	784	786	827	1.00	157.0	1,165	1,151	1,182
Gas 30; do	C-5	1.00	111.0	784	786	827	1.00	157.0	1,165	1,151	1,182

2/ Caterpillar Diesel 50.

3/ McCormick Deering Diesel 40.

Table 19. -- Arch-skidding from stump to railroad with winch-equipped RD 7 Caterpillar tractor and 10-ton arch - Caterpillar Tractor Company at Crossett. (Case A-1)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree-diameter classes.

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	0.33	0.24	0.19	0.15	0.13	0.11	0.10	0.09	0.08	0.07	0.06
500	.39	.28	.22	.18	.16	.14	.13	.12	.11	.10	.09
1,000	.43	.31	.25	.20	.18	.16	.14	.13	.12	.12	.11
2,000	.50	.36	.29	.24	.22	.19	.18	.16	.15	.15	.14
3,000	.57	.42	.34	.28	.26	.23	.21	.19	.19	.18	.17
4,000	.64	.47	.39	.33	.29	.27	.24	.23	.22	.21	.21
5,000	.71	.53	.43	.37	.33	.30	.28	.26	.25	.24	.24
6,000	.78	.58	.48	.41	.37	.34	.31	.29	.28	.28	.27
7,000	.85	.64	.52	.45	.41	.37	.35	.32	.31	.31	.30
8,000	.92	.69	.57	.49	.45	.41	.38	.35	.34	.34	.33

Estimated cost, by tree diameter classes.

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	$1.29	$0.94	$0.74	$0.58	$0.51	$0.43	$0.39	$0.35	$0.31	$0.27	$0.23
500	1.52	1.09	.86	.70	.62	.55	.51	.47	.43	.39	.35
1,000	1.68	1.21	.98	.78	.70	.62	.55	.51	.47	.47	.43
2,000	1.95	1.40	1.13	.94	.86	.74	.70	.62	.58	.58	.55
3,000	2.22	1.64	1.33	1.09	1.01	.90	.82	.74	.74	.70	.66
4,000	2.50	1.83	1.52	1.29	1.13	1.05	.94	.90	.86	.82	.82
5,000	2.77	2.07	1.68	1.44	1.29	1.17	1.09	1.01	.98	.94	.94
6,000	3.04	2.26	1.87	1.60	1.44	1.33	1.21	1.13	1.09	1.09	1.05
7,000	3.32	2.50	2.03	1.76	1.60	1.44	1.36	1.25	1.21	1.21	1.17
8,000	3.59	2.69	2.22	1.91	1.76	1.60	1.48	1.36	1.33	1.33	1.29

Based on: 242 hours of operation; 187 trips; 1,440 tree-length logs totalling 63,603 cubic feet, average skidding distance 5,634 feet, estimated hourly cost of operation $3.90.

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 19 -- Continued.

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	0.94	0.58	0.39	0.28	0.22	0.18	0.15	0.13	0.11	0.10	0.09
500	1.13	.68	.47	.35	.27	.23	.19	.17	.15	.14	.13
1,000	1.23	.75	.52	.39	.31	.26	.22	.19	.17	.16	.15
2,000	1.44	.88	.61	.46	.37	.31	.27	.24	.22	.20	.19
3,000	1.64	1.01	.71	.54	.44	.37	.32	.28	.26	.25	.23
4,000	1.84	1.14	.80	.61	.50	.43	.37	.33	.31	.29	.28
5,000	2.04	1.27	.90	.69	.57	.49	.43	.38	.35	.34	.32
6,000	2.25	1.40	1.00	.76	.64	.54	.48	.42	.40	.38	.36
7,000	2.45	1.53	1.09	.84	.70	.60	.53	.47	.44	.42	.41
8,000	2.65	1.66	1.19	.92	.77	.66	.58	.52	.49	.47	.45

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	$3.67	$2.26	$1.52	$1.09	$0.86	$0.70	$0.58	$0.51	$0.43	$0.39	$0.35
500	4.41	2.65	1.83	1.36	1.05	.90	.74	.66	.58	.55	.51
1,000	4.80	2.92	2.03	1.52	1.21	1.01	.86	.74	.66	.62	.58
2,000	5.62	3.43	2.38	1.79	1.44	1.21	1.05	.94	.86	.78	.74
3,000	6.[illegible]0	3.94	2.77	2.11	1.72	1.44	1.25	1.09	1.01	.98	.90
4,000	7.18	4.45	3.12	2.38	1.95	1.68	1.44	1.29	1.21	1.13	1.09
5,000	7.96	4.95	3.51	2.69	2.22	1.91	1.68	1.48	1.36	1.33	1.25
6,000	8.78	5.46	3.90	2.96	2.50	2.11	1.87	1.64	1.56	1.48	1.40
7,000	9.56	5.97	4.25	3.28	2.73	2.34	2.07	1.83	1.72	1.64	1.60
8,000	10.34	6.47	4.64	3.59	3.00	2.57	2.26	2.03	1.91	1.83	1.76

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 19 -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Skid. dist. (ft.)	Time required in hours, by tree diameter classes										
	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	0.64	0.44	0.33	0.25	0.21	0.17	0.14	0.13	0.11	0.10	0.09
500	.76	.52	.39	.31	.26	.22	.19	.17	.15	.14	.13
1,000	.83	.57	.43	.34	.29	.24	.21	.19	.17	.16	.15
2,000	.97	.67	.51	.41	.35	.30	.26	.23	.22	.20	.19
3,000	1.01	.77	.59	.48	.41	.36	.31	.28	.26	.25	.24
4,000	1.24	.87	.67	.55	.47	.41	.37	.33	.31	.29	.28
5,000	1.38	.97	.76	.61	.53	.47	.42	.37	.35	.34	.32
6,000	1.51	1.07	.84	.68	.59	.52	.47	.42	.40	.38	.37
7,000	1.65	1.17	.92	.75	.65	.58	.52	.47	.44	.42	.41
8,000	1.79	1.27	1.00	.82	.72	.64	.57	.51	.49	.47	.45

Skid. dist. (ft.)	Estimated cost, by tree diameter classes										
	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	$2.50	$1.72	$1.29	$0.98	$0.82	$0.66	$0.55	$0.51	$0.43	$0.39	$0.35
500	2.96	2.03	1.52	1.21	1.01	.86	.74	.66	.58	.55	.51
1,000	3.24	2.22	1.68	1.33	1.13	.94	.82	.74	.66	.62	.58
2,000	3.78	2.61	1.99	1.60	1.36	1.17	1.01	.90	.86	.78	.74
3,000	3.94	3.00	2.30	1.87	1.60	1.40	1.21	1.09	1.01	.98	.94
4,000	4.84	3.39	2.61	2.14	1.83	1.60	1.44	1.29	1.21	1.13	1.09
5,000	5.38	3.78	2.96	2.38	2.07	1.83	1.64	1.44	1.36	1.33	1.25
6,000	5.89	4.17	3.28	2.65	2.30	2.03	1.83	1.64	1.56	1.48	1.44
7,000	6.44	4.56	3.59	2.92	2.54	2.26	2.03	1.83	1.72	1.64	1.60
8,000	6.98	4.95	3.90	3.20	2.81	2.50	2.22	1.99	1.91	1.83	1.76

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 19 -- Continued.

D. Time and cost per M board feet (Int. scale - ¼-in.)

Skid. dist. (ft.)	Time required in hours, by tree diameter classes										
	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	0.51	0.36	0.27	0.22	0.18	0.15	0.13	0.12	0.10	0.09	0.08
500	.61	.43	.33	.27	.22	.19	.17	.16	.14	.13	.12
1,000	.66	.47	.36	.29	.25	.22	.20	.18	.16	.15	.15
2,000	.77	.55	.43	.35	.30	.27	.24	.22	.21	.20	.19
3,000	.88	.63	.50	.41	.36	.32	.29	.26	.25	.24	.23
4,000	.99	.71	.57	.47	.41	.37	.33	.31	.29	.28	.27
5,000	1.10	.79	.63	.53	.47	.42	.38	.35	.33	.32	.32
6,000	1.20	.87	.70	.58	.52	.47	.43	.39	.38	.37	.36
7,000	1.31	.95	.77	.64	.57	.52	.47	.44	.42	.41	.40
8,000	1.42	1.04	.84	.70	.63	.57	.52	.48	.46	.45	.44

Skid. dist. (ft.)	Estimated cost, by tree diameter classes										
	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch
0[1]	$1.99	$1.40	$1.05	$0.86	$0.70	$0.58	$0.51	$0.47	$0.39	$0.35	$0.31
500	2.38	1.68	1.29	1.05	.86	.74	.66	.62	.55	.51	.47
1,000	2.57	1.83	1.40	1.13	.98	.86	.78	.70	.62	.58	.58
2,000	3.00	2.14	1.68	1.36	1.17	1.05	.94	.86	.82	.78	.74
3,000	3.43	2.46	1.95	1.60	1.40	1.25	1.13	1.01	.98	.94	.90
4,000	3.86	2.77	2.22	1.83	1.60	1.44	1.29	1.21	1.13	1.09	1.05
5,000	4.29	3.08	2.46	2.07	1.83	1.64	1.48	1.36	1.29	1.25	1.25
6,000	4.68	3.39	2.73	2.26	2.03	1.83	1.68	1.52	1.48	1.44	1.40
7,000	5.11	3.70	3.00	2.50	2.22	2.03	1.83	1.72	1.64	1.60	1.56
8,000	5.54	4.06	3.28	2.73	2.46	2.22	2.03	1.87	1.79	1.76	1.72

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 20. -- Arch-skidding from bunching point to railroad with winch-equipped RD 7 Caterpillar tractor and 10-ton arch - Caterpillar Tractor Company at Crossett. (Case A-2)

A. Time and cost per 100 cubic feet.

Skid. dist. (ft.)	Time required in hours, by tree diameter classes												
	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.26	0.17	0.13	0.10	0.09	0.07	0.07	0.06	0.05	0.05	0.05	0.04	0.04
2,000	.55	.39	.30	.25	.22	.20	.18	.17	.16	.15	.15	.15	.14
3,000	.62	.44	.35	.29	.25	.23	.21	.20	.19	.18	.17	.17	.17
4,000	.69	.50	.39	.32	.28	.26	.24	.22	.21	.20	.20	.19	.19
5,000	.77	.55	.43	.36	.31	.29	.26	.25	.24	.23	.22	.22	.22
6,000	.84	.60	.47	.39	.35	.31	.29	.27	.26	.25	.25	.24	.24
8,000	.99	.71	.56	.47	.41	.37	.35	.33	.31	.30	.30	.29	.29
10,000	1.13	.82	.65	.54	.47	.43	.40	.38	.36	.35	.34	.34	.34
12,000	1.28	.92	.73	.61	.54	.49	.46	.43	.41	.40	.39	.39	.38

Skid. dist. (ft.)	Estimated cost, by tree diameter classes												
0 1/	$ 1.01	$ 0.66	$ 0.51	$ 0.39	$ 0.35	$ 0.27	$ 0.27	$ 0.23	$ 0.20	$ 0.20	$ 0.20	$ 0.16	$ 0.16
2,000	2.14	1.52	1.17	.98	.86	.78	.70	.66	.62	.58	.58	.58	.55
3,000	2.42	1.72	1.36	1.13	.98	.90	.82	.78	.74	.70	.66	.66	.66
4,000	2.69	1.95	1.52	1.25	1.09	1.01	.94	.86	.82	.78	.78	.74	.74
5,000	3.00	2.14	1.68	1.40	1.21	1.13	1.01	.98	.94	.90	.86	.86	.86
6,000	3.28	2.34	1.83	1.52	1.36	1.21	1.13	1.05	1.01	.98	.98	.94	.94
8,000	3.86	2.77	2.18	1.83	1.60	1.44	1.36	1.29	1.21	1.17	1.17	1.13	1.13
10,000	4.41	3.20	2.54	2.11	1.83	1.68	1.56	1.48	1.40	1.36	1.33	1.33	1.33
12,000	4.99	3.59	2.85	2.38	2.11	1.91	1.79	1.68	1.60	1.56	1.52	1.52	1.48

Based on: 167 hours of operation, 110 trips, 859 tree-length logs totalling 36,616 cubic feet, average skidding distance 9,241 feet, estimated hourly cost of operation $3.90.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 20. -- Continued.

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid-dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.94	0.50	0.31	0.21	0.16	0.13	0.11	0.09	0.08	0.07	0.06	0.06	0.06
2,000	2.01	1.13	.73	.52	.41	.34	.29	.26	.23	.22	.21	.20	.19
3,000	2.28	1.28	.84	.60	.47	.39	.34	.30	.27	.25	.24	.23	.22
4,000	2.54	1.44	.94	.67	.53	.44	.38	.34	.31	.29	.27	.26	.25
5,000	2.81	1.59	1.04	.75	.59	.49	.43	.38	.35	.32	.31	.29	.29
6,000	3.08	1.74	1.14	.82	.65	.54	.47	.42	.38	.36	.34	.33	.32
8,000	3.61	2.05	1.35	.97	.77	.64	.56	.50	.46	.43	.41	.39	.38
10,000	4.14	2.36	1.55	1.12	.89	.75	.65	.58	.53	.50	.47	.46	.45
12,000	4.67	2.67	1.76	1.27	1.01	.85	.74	.66	.60	.57	.54	.52	.51

Estimated cost, by tree diameter classes

Skid-dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$3.67	$1.95	$ 1.21	$ 0.82	$ 0.62	$ 0.51	$ 0.43	$ 0.35	$ 0.31	$ 0.27	$ 0.23	$ 0.25	$ 0.23
2,000	7.84	4.41	2.85	2.03	1.60	1.33	1.13	1.01	.90	.86	.82	.78	.74
3,000	8.89	4.99	3.28	2.34	1.85	1.52	1.33	1.17	1.05	.98	.94	.90	.86
4,000	9.91	5.62	3.67	2.61	2.07	1.72	1.48	1.35	1.21	1.13	1.05	1.01	.98
5,000	10.96	6.20	4.06	2.92	2.30	1.91	1.68	1.48	1.36	1.25	1.21	1.13	1.13
6,000	12.01	6.79	4.45	3.20	2.54	2.11	1.83	1.64	1.48	1.40	1.33	1.29	1.25
8,000	14.08	8.00	5.26	3.78	3.00	2.50	2.18	1.95	1.79	1.68	1.60	1.52	1.48
10,000	16.15	9.20	6.04	4.37	3.47	2.92	2.54	2.26	2.07	1.95	1.83	1.79	1.76
12,000	18.21	10.41	6.86	4.95	3.94	3.32	2.89	2.57	2.34	2.22	2.11	2.03	1.99

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 20. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.53	0.34	0.24	0.18	0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.06
2,000	1.13	.76	.56	.44	.37	.32	.28	.25	.23	.22	.21	.20	.19
3,000	1.28	.86	.64	.50	.42	.36	.32	.29	.27	.25	.24	.23	.22
4,000	1.43	.97	.72	.56	.47	.41	.36	.33	.30	.29	.27	.26	.26
5,000	1.58	1.07	.80	.63	.53	.46	.41	.37	.34	.32	.31	.30	.29
6,000	1.73	1.18	.87	.69	.58	.51	.45	.41	.38	.36	.34	.33	.32
8,000	2.03	1.38	1.03	.82	.69	.60	.53	.49	.45	.43	.41	.40	.39
10,000	2.33	1.59	1.19	.94	.79	.69	.62	.56	.52	.50	.48	.46	.45
12,000	2.62	1.80	1.35	1.07	.90	.79	.70	.64	.60	.57	.54	.53	.52

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$2.07	$ 1.33	$ 0.94	$ 0.70	$ 0.55	$ 0.47	$ 0.39	$ 0.35	$ 0.31	$ 0.27	$ 0.23	$ 0.23	$ 0.23
2,000	4.41	2.96	2.18	1.72	1.44	1.25	1.09	.98	.90	.86	.82	.78	.74
3,000	4.99	3.35	2.50	1.95	1.64	1.40	1.25	1.13	1.05	.98	.94	.90	.86
4,000	5.58	3.78	2.81	2.18	1.83	1.60	1.40	1.29	1.17	1.13	1.05	1.01	1.01
5,000	6.16	4.17	3.12	2.46	2.07	1.79	1.60	1.44	1.33	1.25	1.21	1.17	1.13
6,000	6.75	4.60	3.39	2.69	2.26	1.99	1.76	1.60	1.48	1.40	1.33	1.29	1.25
8,000	7.92	5.38	4.02	3.20	2.69	2.34	2.07	1.91	1.76	1.68	1.60	1.56	1.52
10,000	9.09	6.20	4.64	3.67	3.08	2.69	2.42	2.18	2.05	1.95	1.87	1.79	1.76
12,000	10.22	7.02	5.26	4.17	3.51	3.08	2.73	2.50	2.34	2.22	2.11	2.07	2.03

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 20. -- Continued.

D. Time and cost per M board feet (Int. - $\frac{1}{4}$-in.)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
	Time required in hours, by tree diameter classes												
0[1]	0.41	0.27	0.19	0.15	0.12	0.10	0.09	0.08	0.07	0.07	0.06	0.06	0.06
2,000	.88	.61	.46	.37	.31	.28	.25	.23	.22	.21	.20	.19	.19
3,000	1.00	.69	.52	.42	.36	.32	.29	.27	.25	.24	.23	.23	.22
4,000	1.12	.77	.59	.47	.40	.36	.33	.30	.29	.27	.26	.26	.25
5,000	1.23	.85	.65	.53	.45	.40	.37	.34	.32	.31	.30	.29	.29
6,000	1.35	.94	.71	.58	.50	.44	.40	.37	.35	.34	.33	.32	.32
8,000	1.58	1.10	.84	.68	.59	.53	.48	.44	.42	.40	.39	.39	.38
10,000	1.82	1.27	.97	.79	.68	.61	.56	.52	.49	.47	.46	.45	.45
12,000	2.05	1.43	1.10	.89	.77	.69	.63	.59	.56	.54	.52	.52	.51
	Estimated cost, by tree diameter classes												
0[1]	$1.60	$1.05	0.74	$0.58	$0.47	$0.39	$0.35	$0.31	$0.27	$0.27	$0.23	$0.23	$0.23
2,000	3.43	2.38	1.79	1.44	1.21	1.09	.98	.90	.86	.82	.78	.74	.74
3,000	3.90	2.69	2.03	1.64	1.40	1.25	1.13	1.05	.98	.94	.90	.90	.86
4,000	4.37	3.00	2.30	1.83	1.56	1.40	1.29	1.17	1.13	1.05	1.01	1.01	.98
5,000	4.80	3.32	2.54	2.07	1.76	1.56	1.44	1.33	1.25	1.21	1.17	1.13	1.13
6,000	5.26	3.67	2.77	2.26	1.95	1.72	1.56	1.44	1.36	1.33	1.29	1.25	1.25
8,000	6.16	4.29	3.28	2.65	2.30	2.07	1.87	1.72	1.64	1.56	1.52	1.52	1.48
10,000	7.10	4.95	3.78	3.08	2.65	2.38	2.18	2.03	1.91	1.83	1.79	1.76	1.76
12,000	8.00	5.58	4.29	3.47	3.00	2.69	2.46	2.30	2.18	2.11	2.03	2.03	1.99

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 21.-- Arch-skidding from stump to railroad with winch-equipped Diesel 50 Caterpillar tractor and 10-ton arch - Brooks-Scanlon Corporation. (Case A-3)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0 1/	0.28	0.19	0.14	0.11	0.09	0.08	0.07	0.06	0.05	0.05
500	.40	.27	.20	.16	.14	.13	.11	.10	.10	.09
1,000	.47	.32	.24	.20	.17	.15	.14	.13	.12	.12
2,000	.61	.42	.32	.26	.23	.21	.20	.18	.17	.17
3,000	.75	.52	.39	.33	.29	.27	.25	.24	.23	.22
4,000	.89	.61	.47	.39	.35	.33	.31	.29	.28	.27
5,000	1.03	.71	.54	.46	.41	.38	.36	.34	.33	.32

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0 1/	$1.10	$0.75	$0.55	$0.43	$0.35	$0.32	$0.28	$0.24	$0.20	$0.20
500	1.58	1.06	.79	.63	.55	.51	.43	.39	.39	.35
1,000	1.85	1.26	.95	.79	.67	.59	.55	.51	.47	.47
2,000	2.40	1.65	1.26	1.02	.91	.83	.79	.71	.67	.67
3,000	2.96	2.05	1.54	1.30	1.14	1.06	.98	.95	.91	.87
4,000	3.51	2.40	1.85	1.54	1.38	1.30	1.22	1.14	1.10	1.06
5,000	4.06	2.80	2.13	1.81	1.62	1.50	1.42	1.34	1.30	1.26

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0 1/	1.02	0.54	0.33	0.22	0.16	0.13	0.11	0.09	0.08	0.07
500	1.47	.79	.49	.34	.26	.22	.18	.16	.14	.13
1,000	1.73	.93	.58	.41	.32	.27	.23	.20	.18	.16
2,000	2.24	1.21	.76	.55	.44	.37	.32	.28	.26	.24
3,000	2.75	1.49	.95	.68	.55	.46	.41	.36	.33	.31
4,000	3.25	1.77	1.13	.82	.66	.56	.49	.45	.41	.38
5,000	3.76	2.05	1.31	.96	.78	.66	.58	.53	.48	.45

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0 1/	$4.02	$2.13	$1.30	$0.87	$0.63	$0.51	$0.43	$0.35	$0.32	$0.28
500	5.79	3.11	1.93	1.34	1.02	.87	.71	.63	.55	.51
1,000	6.82	3.66	2.29	1.62	1.26	1.06	.91	.79	.71	.63
2,000	8.83	4.77	2.99	2.17	1.73	1.46	1.26	1.10	1.02	.95
3,000	10.84	5.87	3.74	2.68	2.17	1.81	1.62	1.42	1.30	1.22
4,000	12.80	6.97	4.45	3.23	2.60	2.21	1.93	1.77	1.62	1.50
5,000	14.81	8.08	5.16	3.78	3.07	2.60	2.29	2.09	1.89	1.77

Based on: 78 hours of operation; 100 trips; 877 tree-length logs totalling 26,710 cubic feet; average skidding distance 2,415 feet, estimated hourly cost of operation $3.94.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 21. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0[1]	0.57	0.36	0.25	0.19	0.15	0.12	0.10	0.09	0.08	0.07
500	.83	.53	.38	.29	.24	.20	.18	.16	.14	.13
1,000	.97	.63	.45	.34	.29	.25	.22	.19	.18	.16
2,000	1.26	.82	.58	.46	.39	.34	.30	.27	.25	.24
3,000	1.54	1.01	.72	.57	.49	.43	.39	.35	.33	.31
4,000	1.83	1.19	.86	.69	.59	.52	.47	.43	.40	.38
5,000	2.11	1.38	1.00	.80	.69	.62	.56	.51	.48	.45

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0[1]	$2.25	$1.42	$0.98	$0.75	$0.59	$0.47	$0.39	$0.35	$0.32	$0.28
500	3.27	2.09	1.50	1.14	.95	.79	.71	.63	.55	.51
1,000	3.82	2.48	1.77	1.34	1.14	.98	.87	.75	.71	.63
2,000	4.96	3.23	2.29	1.81	1.54	1.34	1.18	1.06	.98	.95
3,000	6.07	3.98	2.84	2.25	1.93	1.69	1.54	1.38	1.30	1.22
4,000	7.21	4.69	3.39	2.72	2.32	2.05	1.85	1.69	1.58	1.50
5,000	8.31	5.44	3.94	3.15	2.72	2.44	2.21	2.01	1.89	1.77

D. Time and cost per M board feet (Int. - $\frac{1}{4}$-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0[1]	0.45	0.29	0.20	0.16	0.13	0.11	0.09	0.08	0.07	0.06
500	.65	.42	.31	.24	.20	.18	.16	.14	.13	.12
1,000	.76	.50	.36	.29	.25	.22	.20	.18	.17	.16
2,000	.98	.65	.48	.39	.33	.30	.27	.25	.24	.22
3,000	1.20	.80	.59	.48	.42	.38	.35	.32	.31	.29
4,000	1.43	.95	.70	.58	.51	.46	.42	.40	.38	.36
5,000	1.65	1.10	.82	.67	.59	.54	.50	.47	.45	.43

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch
0[1]	$1.77	$1.14	$0.79	$0.63	$0.51	$0.43	$0.35	$0.32	$0.28	$0.24
500	2.56	1.65	1.22	.95	.79	.71	.63	.55	.51	.47
1,000	2.99	1.97	1.42	1.14	.98	.87	.79	.71	.67	.63
2,000	3.86	2.56	1.89	1.54	1.30	1.18	1.06	.98	.95	.87
3,000	4.73	3.15	2.32	1.89	1.65	1.50	1.38	1.26	1.22	1.14
4,000	5.63	3.74	2.76	2.29	2.01	1.81	1.65	1.58	1.50	1.42
5,000	6.50	4.33	3.23	2.64	2.32	2.13	1.97	1.85	1.77	1.69

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 22. -- Arch-skidding from stump to railroad with winch-equipped RD 6 Caterpillar tractor and 6-ton arch - Caterpillar Tractor Company at Crossett. (Case A-4)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.44	0.30	0.22	0.17	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.07
500	.57	.40	.32	.27	.23	.21	.20	.18	.17	.17	.16	.15	.15
1,000	.62	.44	.35	.30	.26	.24	.22	.21	.20	.19	.19	.18	.18
2,000	.70	.50	.41	.36	.32	.30	.28	.27	.26	.25	.24	.24	.23
3,000	.79	.57	.47	.42	.38	.36	.34	.32	.31	.31	.30	.29	.29
4,000	.88	.64	.54	.48	.44	.41	.40	.38	.37	.36	.35	.35	.34
5,000	.96	.71	.60	.54	.50	.47	.45	.44	.43	.42	.41	.40	.40
6,000	1.05	.78	.66	.60	.56	.53	.51	.49	.48	.47	.46	.46	.45
7,000	1.13	.84	.73	.66	.62	.59	.57	.55	.54	.53	.52	.51	.51
8,000	1.22	.91	.79	.72	.68	.64	.62	.61	.59	.58	.58	.57	.56

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$1.44	$ 0.98	$ 0.72	$ 0.56	$ 0.46	$ 0.39	$ 0.36	$ 0.33	$ 0.29	$ 0.26	$ 0.26	$ 0.23	$ 0.23
500	1.86	1.31	1.05	.88	.75	.69	.65	.59	.56	.56	.52	.49	.49
1,000	2.03	1.44	1.14	.98	.85	.78	.72	.69	.65	.62	.62	.59	.59
2,000	2.29	1.64	1.34	1.18	1.05	.98	.92	.88	.85	.82	.78	.78	.75
3,000	2.58	1.86	1.54	1.37	1.24	1.18	1.11	1.05	1.01	1.01	.98	.95	.95
4,000	2.88	2.09	1.77	1.57	1.44	1.34	1.31	1.24	1.21	1.18	1.14	1.14	1.11
5,000	3.14	2.32	1.96	1.77	1.64	1.54	1.47	1.44	1.41	1.37	1.34	1.31	1.31
6,000	3.43	2.55	2.16	1.96	1.83	1.73	1.67	1.60	1.57	1.54	1.50	1.50	1.47
7,000	3.70	2.75	2.39	2.16	2.03	1.93	1.86	1.80	1.77	1.73	1.70	1.67	1.67
8,000	3.99	2.98	2.58	2.35	2.22	2.09	2.03	1.99	1.93	1.90	1.90	1.86	1.83

Based on: 149 hours of operation; 172 trips; 931 tree-length logs totalling 40,882 cubic feet; average skidding distance 2,853 feet; estimated hourly cost of operation $3.27.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 22. -- Continued.

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	1.61	0.86	0.53	0.36	0.27	0.21	0.18	0.15	0.13	0.12	0.10	0.10	0.09
500	2.10	1.16	.76	.56	.44	..37	.32	.28	.26	.24	.22	.21	.20
1,000	2.26	1.26	.84	.62	.50	.42	.36	.32	.30	.27	.26	.25	.24
2,000	2.58	1.46	.99	.75	.61	.51	.45	.41	.38	.35	.34	.32	.31
3,000	2.89	1.65	1.14	.87	.72	.61	.55	.50	.46	.43	.41	.39	.38
4,000	3.21	1.85	1.29	1.00	.83	.71	.64	.58	.54	.51	.49	.47	.46
5,000	3.52	2.04	1.44	1.13	.94	.81	.73	.67	.62	.59	.56	.54	.53
6,000	3.84	2.24	1.60	1.25	1.05	.91	.82	.76	.71	.67	.64	.62	.60
7,000	4.15	2.44	1.75	1.38	1.16	1.01	.91	.84	.79	.75	.72	.69	.67
8,000	4.47	2.63	1.90	1.51	1.27	1.11	1.01	.93	.87	.83	.79	.77	.75

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$5.26	$ 2.81	$ 1.73	$ 1.18	$ 0.88	$ 0.69	$ 0.59	$ 0.49	$ 0.43	$ 0.39	$ 0.33	$ 0.33	$ 0.29
500	6.87	3.79	2.49	1.83	1.44	1.21	1.05	.92	.85	.78	.72	.69	.65
1,000	7.39	4.12	2.75	2.03	1.64	1.37	1.18	1.05	.98	.88	.85	.82	.78
2,000	8.44	4.77	3.24	2.45	1.99	1.67	1.47	1.34	1.24	1.14	1.11	1.05	1.01
3,000	9.45	5.40	3.73	2.84	2.35	1.99	1.80	1.64	1.50	1.41	1.34	1.28	1.24
4,000	10.50	6.05	4.22	3.27	2.71	2.32	2.09	1.90	1.77	1.67	1.60	1.54	1.50
5,000	11.51	6.67	4.71	3.70	3.07	2.65	2.39	2.19	2.03	1.93	1.83	1.77	1.73
6,000	12.56	7.32	5.23	4.09	3.43	2.98	2.68	2.49	2.32	2.19	2.09	2.03	1.96
7,000	13.57	7.98	5.72	4.51	3.79	3.30	2.98	2.75	2.58	2.45	2.35	2.26	2.19
8,000	14.62	8.60	6.21	4.94	4.15	3.63	3.30	3.04	2.84	2.71	2.58	2.52	2.45

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 22. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.91	0.58	0.40	0.30	0.24	0.20	0.17	0.15	0.13	0.12	0.11	0.10	0.09
500	1.18	.78	.58	.47	.39	.34	.30	.27	.25	.23	.22	.21	.20
1,000	1.27	.85	.64	.52	.44	.39	.35	.32	.29	.27	.26	.25	.24
2,000	1.45	.98	.76	.63	.54	.48	.44	.40	.37	.35	.34	.32	.31
3,000	1.62	1.11	.87	.73	.64	.57	.52	.48	.45	.43	.41	.40	.39
4,000	1.80	1.25	.99	.84	.74	.66	.61	.57	.53	.51	.49	.47	.46
5,000	1.98	1.38	1.10	.95	.84	.76	.70	.65	.61	.59	.57	.55	.54
6,000	2.16	1.51	1.22	1.05	.94	.85	.79	.74	.70	.67	.64	.62	.61
7,000	2.33	1.64	1.34	1.16	1.03	.94	.88	.82	.78	.75	.72	.70	.68
8,000	2.51	1.78	1.45	1.26	1.13	1.03	.96	.90	.86	.82	.80	.78	.76

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
		$	$	$	$	$	$	$	$	$	$	$	$
0 1/	$2.98	1.90	1.31	0.98	0.78	0.65	0.56	0.49	0.43	0.39	0.36	0.33	0.29
500	3.86	2.55	1.90	1.54	1.28	1.11	.98	.88	.82	.75	.72	.69	.65
1,000	4.15	2.78	2.09	1.70	1.44	1.28	1.14	1.05	.95	.88	.85	.82	.78
2,000	4.74	3.20	2.49	2.06	1.77	1.57	1.44	1.31	1.21	1.14	1.11	1.05	1.01
3,000	5.30	3.63	2.84	2.39	2.09	1.86	1.70	1.57	1.47	1.41	1.34	1.31	1.28
4,000	5.89	4.09	3.24	2.75	2.42	2.16	1.99	1.86	1.73	1.67	1.60	1.54	1.50
5,000	6.47	4.51	3.60	3.11	2.75	2.49	2.29	2.13	1.99	1.93	1.86	1.80	1.77
6,000	7.06	4.94	3.99	3.43	3.07	2.78	2.58	2.42	2.29	2.19	2.09	2.03	1.99
7,000	7.62	5.36	4.38	3.79	3.37	3.07	2.88	2.68	2.55	2.45	2.35	2.29	2.22
8,000	8.21	5.82	4.74	4.12	3.70	3.37	3.14	2.94	2.81	2.68	2.62	2.55	2.49

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 22. -- Continued.

D. Time and cost per M board feet (Int. - 1/4-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.71	0.46	0.33	0.25	0.21	0.18	0.15	0.14	0.12	0.11	0.10	0.09	0.09
500	.92	.62	.47	.39	.34	.30	.27	.25	.24	.22	.21	.21	.20
1,000	.99	.68	.52	.44	.38	.34	.31	.29	.27	.26	.25	.24	.24
2,000	1.13	.78	.62	.52	.46	.42	.39	.37	.35	.34	.32	.32	.31
3,000	1.27	.89	.71	.61	.55	.50	.47	.44	.43	.41	.40	.39	.38
4,000	1.41	.99	.81	.70	.63	.58	.55	.52	.50	.48	.47	.46	.45
5,000	1.55	1.10	.90	.79	.72	.66	.63	.60	.58	.56	.55	.53	.53
6,000	1.68	1.20	1.00	.88	.80	.75	.71	.67	.65	.63	.62	.61	.60
7,000	1.82	1.31	1.09	.97	.89	.83	.79	.75	.73	.71	.69	.68	.67
8,000	1.96	1.41	1.19	1.06	.97	.91	.86	.83	.80	.78	.77	.75	.74

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$2.32	$1.50	$1.08	$0.82	$0.69	$0.59	$0.49	$0.46	$0.39	$0.36	$0.33	$0.29	$0.29
500	3.01	2.03	1.54	1.28	1.11	.98	.88	.82	.78	.72	.69	.69	.65
1,000	3.24	2.22	1.70	1.44	1.24	1.11	1.01	.95	.88	.85	.82	.78	.78
2,000	3.70	2.55	2.03	1.70	1.50	1.37	1.28	1.21	1.14	1.11	1.05	1.05	1.01
3,000	4.15	2.91	2.32	1.99	1.80	1.64	1.54	1.44	1.41	1.34	1.31	1.28	1.24
4,000	4.61	3.24	2.65	2.29	2.06	1.90	1.80	1.70	1.64	1.57	1.54	1.50	1.47
5,000	5.07	3.60	2.94	2.58	2.35	2.16	2.06	1.96	1.90	1.83	1.80	1.73	1.73
6,000	5.49	3.92	3.27	2.88	2.62	2.45	2.32	2.19	2.13	2.06	2.03	1.99	1.96
7,000	5.95	4.28	3.56	3.17	2.91	2.71	2.58	2.45	2.39	2.32	2.26	2.22	2.19
8,000	6.41	4.61	3.89	3.47	3.17	2.98	2.81	2.71	2.62	2.55	2.52	2.45	2.42

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 23. -- Pan-skidding from stump to railroad with winch-equipped RD 7 Caterpillar tractor and skidding pan - Brooks - Scanlon Corporation. (Case B-1)

A. Time and cost per 100 cubic feet

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0[1]	0.33	0.21	0.14	0.10	0.08	0.06	0.05	0.04	0.03
500	.45	.29	.21	.17	.14	.12	.11	.10	.09
1,000	.51	.34	.25	.20	.17	.16	.14	.13	.13
2,000	.63	.43	.32	.27	.24	.22	.21	.20	.20
3,000	.75	.52	.40	.34	.31	.29	.28	.27	.27
4,000	.88	.61	.47	.40	.38	.36	.35	.34	.34
5,000	1.00	.71	.55	.47	.45	.43	.42	.41	.41
	Estimated cost, by tree diameter classes								
0[1]	$1.08	$0.68	$0.46	$0.33	$0.26	$0.20	$0.16	$0.13	$0.10
500	1.47	.95	.68	.55	.46	.39	.36	.33	.29
1,000	1.66	1.11	.82	.65	.55	.52	.46	.42	.42
2,000	2.05	1.40	1.04	.88	.78	.72	.68	.65	.65
3,000	2.44	1.70	1.30	1.11	1.01	.95	.91	.88	.88
4,000	2.87	1.99	1.53	1.30	1.24	1.17	1.14	1.11	1.11
5,000	3.26	2.31	1.79	1.53	1.47	1.40	1.37	1.34	1.34

B. Time and cost per M board feet (Doyle-Scribner)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0[1]	1.22	0.60	0.34	0.21	0.14	0.10	0.08	0.06	0.04
500	1.63	.85	.51	.34	.26	.21	.17	.15	.13
1,000	1.86	.98	.60	.42	.33	.27	.23	.20	.18
2,000	2.31	1.25	.78	.56	.46	.39	.34	.31	.29
3,000	2.76	1.51	.96	.70	.58	.51	.45	.42	.39
4,000	3.21	1.77	1.14	.84	.71	.63	.57	.53	.49
5,000	3.66	2.04	1.32	.98	.84	.75	.68	.63	.60
	Estimated cost, by tree diameter classes								
0[1]	$3.98	$1.96	$1.11	$0.68	$0.46	$0.33	$0.26	$0.20	$0.13
500	5.31	2.77	1.66	1.11	.85	.68	.55	.49	.42
1,000	6.06	3.19	1.96	1.37	1.08	.88	.75	.65	.59
2,000	7.53	4.08	2.54	1.83	1.50	1.27	1.11	1.01	.95
3,000	9.00	4.92	3.13	2.28	1.89	1.66	1.47	1.37	1.27
4,000	10.46	5.77	3.72	2.74	2.31	2.05	1.86	1.73	1.60
5,000	11.93	6.65	4.30	3.19	2.74	2.44	2.22	2.05	1.96

Based on: 56 hours of operation, 82 trips, 536 tree-length logs totalling 16,835 cubic feet, average skidding distance 2,677 feet, estimated hourly cost of operation $3.26.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 23. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0[1]	0.68	0.41	0.26	0.18	0.13	0.10	0.07	0.05	0.04
500	.92	.57	.39	.29	.23	.19	.17	.15	.13
1,000	1.04	.66	.46	.35	.29	.25	.22	.20	.18
2,000	1.30	.84	.60	.47	.40	.36	.33	.30	.28
3,000	1.55	1.02	.74	.59	.52	.47	.44	.41	.38
4,000	1.80	1.20	.87	.71	.64	.58	.54	.51	.49
5,000	2.06	1.37	1.01	.83	.75	.69	.65	.62	.59
	Estimated cost, by tree diameter classes								
0[1]	$2.22	$1.34	$0.85	$0.59	$0.42	$0.33	$0.23	$0.16	$0.13
500	3.00	1.86	1.27	.95	.75	.62	.55	.49	.42
1,000	3.39	2.15	1.50	1.14	.95	.82	.72	.65	.59
2,000	4.24	2.74	1.96	1.53	1.30	1.17	1.08	.98	.91
3,000	5.05	3.33	2.41	1.92	1.70	1.53	1.43	1.34	1.24
4,000	5.87	3.91	2.84	2.31	2.09	1.89	1.76	1.66	1.60
5,000	6.72	4.47	3.29	2.71	2.44	2.25	2.12	2.02	1.92

D. Time and cost per M board feet (Int. scale - ¼-in.)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0[1]	0.54	0.32	0.21	0.15	0.11	0.08	0.06	0.05	0.04
500	.72	.46	.32	.24	.20	.17	.15	.13	.12
1,000	.82	.53	.38	.29	.25	.22	.20	.18	.17
2,000	1.01	.67	.49	.39	.35	.32	.29	.28	.27
3,000	1.21	.81	.60	.49	.45	.41	.39	.37	.36
4,000	1.41	.95	.71	.59	.54	.51	.49	.47	.46
5,000	1.61	1.09	.83	.69	.64	.61	.58	.57	.55
	Estimated cost, by tree diameter classes								
0[1]	$1.76	$1.04	$0.68	$0.49	$0.36	$0.26	$0.20	$0.16	$0.13
500	2.35	1.50	1.04	.78	.65	.55	.49	.42	.39
1,000	2.67	1.73	1.24	.95	.82	.72	.65	.59	.55
2,000	3.29	2.18	1.60	1.27	1.14	1.04	.95	.91	.88
3,000	3.94	2.64	1.96	1.60	1.47	1.34	1.27	1.21	1.17
4,000	4.60	3.10	2.31	1.92	1.76	1.66	1.60	1.53	1.50
5,000	5.25	3.55	2.71	2.25	2.09	1.99	1.89	1.86	1.79

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 24. -- Pan-skidding from stump to railroad with winch-equipped RD 6 Caterpillar tractor and skidding pan - Jackson Lumber Company (Case B-2)

A. Time and cost per 100 cubic feet

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0 1/	0.14	0.11	0.09	0.08	0.07	0.07	0.07	0.06
2,000	.43	.33	.28	.25	.23	.22	.21	.20
3,000	.48	.38	.32	.29	.26	.25	.24	.23
4,000	.53	.42	.36	.32	.29	.28	.27	.26
5,000	.58	.46	.39	.35	.32	.31	.29	.28

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0 1/	$0.35	$0.28	$0.23	$0.20	$0.18	$0.18	$0.18	$0.15
2,000	1.08	.83	.71	.63	.58	.55	.53	.50
3,000	1.21	.96	.81	.73	.66	.63	.60	.58
4,000	1.34	1.06	.91	.81	.73	.71	.68	.66
5,000	1.46	1.16	.98	.88	.81	.78	.73	.71

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0 1/	0.53	0.32	0.22	0.17	0.14	0.12	0.11	0.10
2,000	1.57	.97	.68	.53	.44	.38	.34	.31
3,000	1.76	1.09	.77	.60	.50	.43	.39	.35
4,000	1.95	1.21	.86	.66	.56	.48	.43	.39
5,000	2.14	1.33	.94	.73	.61	.53	.48	.43

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0 1/	$1.34	$0.81	$0.55	$0.43	$0.35	$0.30	$0.28	$0.25
2,000	3.96	2.44	1.71	1.34	1.11	.96	.86	.78
3,000	4.44	2.75	1.94	1.51	1.26	1.08	.98	.88
4,000	4.91	3.05	2.17	1.66	1.41	1.21	1.08	.98
5,000	5.39	3.35	2.37	1.84	1.54	1.34	1.21	1.08

Based on: 52 hours of operation; 78 trips; 654 tree-length logs totalling 15,295 cubic feet; average skidding distance 3,655 feet; estimated hourly cost of operation $2.52.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 24. Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
	Time required in hours, by tree diameter classes							
0 1/	0.30	0.21	0.17	0.14	0.12	0.11	0.10	0.09
2,000	.88	.65	.52	.44	.39	.36	.33	.30
3,000	.99	.73	.59	.50	.44	.40	.37	.34
4,000	1.10	.81	.66	.56	.49	.45	.41	.38
5,000	1.20	.89	.72	.61	.54	.49	.46	.42
	Estimated cost, by tree diameter classes							
0 1/	$0.76	$0.53	$0.43	$0.35	$0.30	$0.28	$0.25	$0.23
2,000	2.22	1.64	1.31	1.11	.98	.91	.83	.76
3,000	2.49	1.84	1.49	1.26	1.11	1.01	.93	.86
4,000	2.77	2.04	1.66	1.41	1.23	1.13	1.03	.96
5,000	3.02	2.24	1.81	1.54	1.36	1.23	1.16	1.06

D. Time and cost per M board feet (Int. scale - ¼-in.)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
	Time required in hours, by tree diameter classes							
0 1/	0.23	0.17	0.14	0.12	0.11	0.10	0.09	0.09
2,000	.69	.52	.43	.37	.34	.31	.29	.28
3,000	.77	.58	.48	.42	.38	.35	.33	.31
4,000	.86	.65	.54	.47	.42	.39	.37	.35
5,000	.94	.71	.59	.51	.47	.43	.41	.39
	Estimated cost, by tree diameter classes							
0 1/	$0.58	$0.43	$0.35	$0.30	$0.28	$0.25	$0.23	$0.23
2,000	1.74	1.31	1.08	.93	.86	.78	.73	.71
3,000	1.94	1.46	1.21	1.06	.96	.88	.83	.78
4,000	2.17	1.64	1.36	1.18	1.06	.98	.93	.88
5,000	2.37	1.79	1.49	1.29	1.18	1.08	1.03	.98

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 25. -- Ground-skidding from stump to railroad with winch-equipped RD 6 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-1)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.52	0.26	0.16	0.12	0.10	0.08	0.07	0.06	0.04	0.03	0.03	0.03	0.03
500	.88	.60	.44	.34	.29	.25	.22	.19	.18	.16	.15	.14	.12
1,000	1.19	.84	.62	.49	.42	.37	.33	.29	.27	.25	.23	.21	.19
1,500	1.51	1.07	.79	.64	.56	.49	.44	.38	.37	.33	.32	.28	.26
2,000	1.82	1.30	.97	.79	.70	.62	.55	.48	.47	.41	.40	.34	.33
2,500	2.14	1.53	1.15	.94	.83	.74	.66	.58	.56	.49	.48	.41	.40

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$1.20	$ 0.60	$ 0.37	$ 0.28	$ 0.23	$ 0.18	$ 0.16	$ 0.14	$ 0.09	$ 0.07	$ 0.07	$ 0.07	$ 0.07
500	2.03	1.39	1.02	.79	.67	.58	.51	.44	.42	.37	.35	.32	.28
1,000	2.75	1.94	1.43	1.13	.97	.85	.76	.67	.62	.58	.53	.49	.44
1,500	3.49	2.47	1.82	1.48	1.29	1.13	1.02	.88	.85	.76	.74	.65	.60
2,000	4.20	3.00	2.24	1.82	1.62	1.43	1.27	1.11	1.09	.95	.92	.79	.76
2,500	4.94	3.53	2.66	2.17	1.92	1.71	1.52	1.34	1.29	1.13	1.11	.95	.92

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	1.90	0.75	0.40	0.26	0.19	0.14	0.11	0.08	0.06	0.04	0.04	0.04	0.04
500	3.21	1.74	1.06	.71	.54	.42	.35	.29	.26	.23	.21	.18	.16
1,000	4.36	2.41	1.48	1.02	.80	.64	.53	.44	.40	.35	.32	.28	.25
1,500	5.52	3.09	1.91	1.34	1.05	.85	.71	.59	.54	.46	.44	.37	.34
2,000	6.67	3.76	2.34	1.65	1.31	1.06	.88	.74	.68	.58	.55	.46	.43
2,500	7.82	4.43	2.77	1.96	1.56	1.27	1.06	.83	.82	.70	.67	.56	.52

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$4.39	$ 1.73	$ 0.92	$ 0.60	$ 0.44	$ 0.32	$ 0.25	$ 0.18	$ 0.14	$ 0.09	$ 0.09	$ 0.09	$ 0.09
500	7.42	4.02	2.45	1.64	1.25	.97	.81	.67	.60	.53	.49	.42	.37
1,000	10.07	5.57	3.42	2.36	1.85	1.48	1.22	1.02	.92	.81	.74	.65	.58
1,500	12.75	7.14	4.41	3.10	2.43	1.96	1.64	1.36	1.25	1.06	1.02	.85	.79
2,000	15.41	8.69	5.41	3.81	3.03	2.45	2.03	1.71	1.57	1.34	1.27	1.06	.99
2,500	18.06	10.23	6.40	4.53	3.60	2.93	2.45	2.03	1.89	1.62	1.55	1.29	1.20

Based on: 146 hours of operation, 643 trips, 982 tree-length logs totalling 64,884 cubic feet, average skidding distance 552 feet, estimated hourly cost of operation $2.31.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 25. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	1.07	0.51	0.30	0.22	0.17	0.13	0.11	0.08	0.06	0.04	0.04	0.04	0.04
500	1.80	1.17	.81	.60	.48	.40	.34	.29	.26	.23	.21	.19	.17
1,000	2.45	1.63	1.13	.86	.71	.59	.51	.43	.40	.35	.32	.28	.26
1,500	3.10	2.08	1.46	1.12	.94	.79	.68	.57	.54	.46	.44	.38	.35
2,000	3.75	2.54	1.79	1.38	1.16	.99	.85	.72	.67	.58	.55	.47	.44
2,500	4.40	2.99	2.12	1.65	1.39	1.18	1.02	.86	.81	.70	.67	.56	.53

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$2.47	$1.18	$0.69	$0.51	$0.39	$0.30	$0.25	$0.18	$0.14	$0.09	$0.09	$0.09	$0.09
500	4.16	2.70	1.87	1.39	1.11	.92	.79	.67	.60	.53	.49	.44	.39
1,000	5.66	3.77	2.61	1.99	1.64	1.36	1.18	.99	.92	.81	.74	.65	.60
1,500	7.16	4.80	3.37	2.59	2.17	1.82	1.57	1.32	1.25	1.06	1.02	.88	.81
2,000	8.66	5.87	4.13	3.19	2.68	2.29	1.96	1.66	1.55	1.34	1.27	1.09	1.02
2,500	10.16	6.91	4.90	3.81	3.21	2.73	2.36	1.99	1.87	1.62	1.55	1.29	1.22

D. Time and cost per M board feet (Int. scale - $\frac{1}{4}$-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.84	0.40	0.25	0.18	0.15	0.12	0.09	0.08	0.06	0.04	0.04	0.04	0.04
500	1.41	.93	.66	.50	.41	.35	.30	.26	.24	.22	.20	.18	.16
1,000	1.92	1.30	.93	.72	.61	.52	.46	.39	.37	.33	.31	.27	.25
1,500	2.42	1.66	1.19	.94	.80	.69	.61	.52	.50	.44	.42	.36	.34
2,000	2.93	2.02	1.46	1.16	1.00	.87	.76	.66	.63	.55	.53	.46	.43
2,500	3.43	2.38	1.73	1.38	1.19	1.04	.91	.79	.76	.66	.64	.55	.52

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$1.94	$0.92	$0.58	$0.42	$0.35	$0.28	$0.21	$0.18	$0.14	$0.09	$0.09	$0.09	$0.09
500	3.26	2.15	1.52	1.16	.95	.81	.69	.60	.55	.51	.46	.42	.37
1,000	4.44	3.00	2.15	1.66	1.41	1.20	1.06	.90	.85	.76	.72	.62	.58
1,500	5.59	3.83	2.75	2.17	1.85	1.59	1.41	1.20	1.16	1.02	.97	.83	.79
2,000	6.77	4.67	3.37	2.68	2.31	2.01	1.76	1.52	1.46	1.27	1.22	1.06	.99
2,500	7.92	5.50	4.00	3.19	2.75	2.40	2.10	1.82	1.76	1.52	1.48	1.27	1.20

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 26.-- Ground-skidding from stump to railroad with McCormick-Deering Diesel 40 tractor (without winch) - Pearl River Valley Lumber Company. (Case C-2)

A. Time and cost per 100 cubic feet.

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
	Time required in hours, by tree diameter classes							
0[1]	0.20	0.14	0.09	0.07	0.05	0.04	0.04	0.03
200	.34	.23	.17	.13	.11	.10	.09	.09
400	.40	.27	.20	.16	.14	.12	.12	.11
500	.43	.29	.22	.18	.15	.14	.13	.12
600	.46	.31	.23	.19	.17	.15	.14	.13
800	.52	.35	.27	.22	.20	.17	.16	.15
1,000	.58	.39	.30	.25	.22	.20	.19	.17
	Estimated cost, by tree diameter classes							
0[1]	$0.45	$0.32	$0.20	$0.16	$0.11	$0.09	$0.09	$0.07
200	.76	.52	.38	.29	.25	.22	.20	.20
400	.90	.61	.45	.36	.32	.27	.27	.25
500	.97	.65	.50	.40	.34	.32	.29	.27
600	1.04	.70	.52	.43	.38	.34	.32	.29
800	1.17	.76	.61	.50	.45	.38	.36	.34
1,000	1.30	.88	.68	.56	.50	.45	.43	.38

B. Time and cost per M board feet (Doyle-Scribner)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
	Time required in hours, by tree diameter classes							
0[1]	0.73	0.39	0.22	0.14	0.10	0.08	0.06	0.05
200	1.23	.66	.40	.28	.22	.17	.15	.13
400	1.45	.78	.48	.34	.27	.22	.19	.16
500	1.56	.83	.52	.37	.29	.24	.21	.18
600	1.68	.89	.56	.40	.32	.26	.23	.20
800	1.90	1.00	.65	.46	.37	.30	.26	.23
1,000	2.12	1.12	.73	.52	.42	.34	.30	.27
	Estimated cost, by tree diameter classes							
0[1]	$1.64	$0.88	$0.50	$0.32	$0.22	$0.18	$0.14	$0.11
200	2.77	1.48	.90	.63	.50	.38	.34	.29
400	3.26	1.76	1.08	.76	.61	.50	.43	.36
500	3.51	1.87	1.17	.83	.65	.54	.47	.40
600	3.78	2.00	1.26	.90	.72	.58	.52	.45
800	4.28	2.25	1.46	1.04	.83	.68	.58	.52
1,000	4.77	2.52	1.64	1.17	.94	.76	.68	.61

Based on: 58 hours of operation; 348 trips; 1,268 forty-foot-maximum-length logs totalling 30,185 cubic feet; average skidding distance 353 feet; estimated hourly cost of operation $2.25.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 26. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0[1]	0.41	0.26	0.17	0.12	0.09	0.07	0.06	0.05
200	.69	.45	.31	.23	.19	.16	.14	.13
400	.82	.52	.37	.28	.24	.20	.18	.16
500	.88	.56	.40	.31	.26	.22	.20	.18
600	.94	.60	.43	.33	.28	.24	.22	.19
800	1.07	.68	.49	.38	.33	.28	.25	.23
1,000	1.19	.75	.56	.44	.37	.32	.29	.26

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0[1]	$0.92	$0.58	$0.38	$0.27	$0.20	$0.16	$0.14	$0.11
200	1.55	1.01	.70	.52	.43	.36	.32	.29
400	1.84	1.17	.83	.63	.54	.45	.40	.36
500	1.98	1.26	.90	.70	.58	.50	.45	.40
600	2.12	1.35	.97	.74	.63	.54	.50	.43
800	2.41	1.53	1.10	.86	.74	.63	.56	.52
1,000	2.68	1.69	1.26	.99	.83	.72	.65	.58

D. Time and cost per M board feet (Int. scale - $\frac{1}{4}$-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0[1]	0.32	0.21	0.14	0.10	0.08	0.06	0.05	0.04
200	.54	.36	.25	.20	.16	.14	.13	.12
400	.64	.42	.30	.24	.20	.18	.16	.15
500	.69	.45	.33	.26	.22	.19	.18	.16
600	.74	.48	.35	.28	.24	.21	.19	.18
800	.83	.54	.40	.32	.28	.24	.23	.21
1,000	.93	.60	.45	.36	.32	.28	.26	.24

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch
0[1]	$0.72	$0.47	$0.32	$0.22	$0.18	$0.14	$0.11	$0.09
200	1.22	.81	.56	.45	.36	.32	.29	.27
400	1.44	.94	.68	.54	.45	.40	.36	.34
500	1.55	1.01	.74	.58	.50	.43	.40	.36
600	1.66	1.08	.79	.63	.54	.47	.43	.40
800	1.87	1.22	.90	.72	.63	.54	.52	.47
1,000	2.09	1.35	1.01	.81	.72	.63	.58	.54

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 27. -- Ground-skidding from stump to railroad with winch-equipped RD 4 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-3)

A. Time and cost per 100 cubic feet.

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
	Time required in hours, by tree diameter classes												
0[1]	0.27	0.18	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.04	0.03	0.03
200	.56	.39	.30	.25	.21	.19	.17	.16	.15	.13	.12	.12	.11
400	.69	.50	.39	.32	.29	.26	.24	.22	.21	.19	.18	.17	.17
500	.76	.55	.44	.36	.32	.29	.27	.25	.24	.22	.21	.20	.19
600	.83	.60	.48	.40	.36	.33	.30	.28	.27	.25	.24	.23	.22
800	.96	.70	.57	.48	.43	.40	.37	.35	.33	.31	.30	.28	.27
1,000	1.10	.81	.66	.56	.51	.47	.44	.41	.39	.37	.36	.34	.33
1,200	1.23	.91	.75	.64	.58	.54	.50	.47	.46	.43	.41	.39	.38
1,500	1.43	1.07	.89	.76	.69	.64	.60	.57	.55	.52	.50	.48	.47
	Estimated cost, by tree diameter classes												
0[1]	$0.52	$ 0.35	$ 0.25	$ 0.19	$ 0.16	$ 0.14	$ 0.12	$ 0.10	$ 0.08	$ 0.08	$ 0.08	$ 0.06	$ 0.06
200	1.09	.76	.58	.48	.41	.37	.33	.31	.29	.25	.23	.23	.21
400	1.34	.97	.76	.62	.56	.50	.47	.43	.41	.37	.35	.33	.33
500	1.47	1.07	.85	.70	.62	.56	.52	.48	.47	.43	.41	.39	.37
600	1.61	1.16	.93	.78	.70	.64	.58	.54	.52	.48	.47	.45	.43
800	1.86	1.36	1.11	.93	.83	.78	.72	.68	.64	.60	.58	.54	.52
1,000	2.13	1.57	1.28	1.09	.99	.91	.85	.80	.76	.72	.70	.66	.64
1,200	2.39	1.77	1.46	1.24	1.13	1.05	.97	.91	.89	.83	.80	.76	.74
1,500	2.77	2.08	1.73	1.47	1.34	1.24	1.16	1.11	1.07	1.01	.97	.93	.91

Based on: 92 hours of operation; 403 trips; 564 tree-length logs totalling 28,152 cubic feet, average skidding distance 612 feet, estimated hourly cost of operation $1.94.

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 27. -- Continued.

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.98	0.51	0.31	0.20	0.15	0.11	0.09	0.08	0.06	0.06	0.05	0.04	0.04
200	2.05	1.13	.73	.51	.40	.32	.27	.24	.21	.19	.17	.16	.15
400	2.54	1.43	.94	.68	.54	.44	.38	.34	.31	.28	.25	.23	.22
500	2.79	1.58	1.05	.76	.61	.50	.43	.38	.35	.32	.29	.27	.26
600	3.03	1.73	1.16	.84	.68	.56	.49	.43	.40	.36	.33	.31	.29
800	3.53	2.04	1.38	1.01	.82	.68	.59	.53	.49	.45	.41	.38	.36
1,000	4.02	2.34	1.59	1.17	.96	.80	.70	.63	.58	.53	.49	.46	.44
1,200	4.51	2.64	1.81	1.34	1.10	.92	.81	.72	.67	.62	.57	.53	.51
1,500	5.25	3.10	2.14	1.59	1.31	1.10	.97	.87	.81	.74	.69	.64	.62

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$1.90	$ 0.99	$ 0.60	$ 0.39	$ 0.29	$ 0.21	$ 0.17	$ 0.16	$ 0.12	$ 0.12	$ 0.10	$ 0.08	$ 0.08
200	3.98	2.19	1.42	.99	.78	.62	.52	.47	.41	.37	.33	.31	.29
400	4.93	2.77	1.82	1.32	1.05	.85	.74	.66	.60	.54	.48	.45	.43
500	5.41	3.07	2.04	1.47	1.18	.97	.83	.74	.68	.62	.56	.52	.50
600	5.88	3.36	2.25	1.63	1.32	1.09	.95	.83	.78	.70	.64	.60	.56
800	6.85	3.96	2.68	1.96	1.59	1.32	1.14	1.03	.95	.87	.80	.74	.70
1,000	7.80	4.54	3.08	2.27	1.86	1.55	1.36	1.22	1.13	1.03	.95	.89	.85
1,200	8.75	5.12	3.51	2.60	2.13	1.78	1.57	1.40	1.30	1.20	1.11	1.03	.99
1,500	10.18	6.01	4.15	3.08	2.54	2.13	1.88	1.69	1.57	1.44	1.34	1.24	1.20

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 27. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.55	0.35	0.23	0.17	0.13	0.11	0.09	0.07	0.06	0.06	0.05	0.04	0.04
200	1.15	.76	.55	.43	.35	.30	.26	.23	.21	.19	.17	.16	.15
400	1.43	.97	.72	.57	.48	.41	.37	.33	.30	.28	.25	.23	.22
500	1.56	1.07	.80	.64	.54	.47	.42	.37	.35	.32	.29	.27	.26
600	1.70	1.17	.89	.71	.60	.53	.47	.42	.39	.36	.33	.31	.30
800	1.98	1.37	1.05	.85	.73	.64	.57	.52	.48	.44	.41	.39	.37
1,000	2.26	1.58	1.22	.98	.85	.75	.67	.61	.57	.53	.49	.46	.44
1,200	2.54	1.78	1.38	1.12	.98	.86	.77	.70	.66	.61	.57	.54	.52
1,500	2.95	2.09	1.63	1.33	1.16	1.03	.93	.85	.79	.74	.69	.65	.63

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$1.07	$ 0.68	$ 0.45	$ 0.33	$ 0.25	$ 0.21	$ 0.17	$ 0.14	$ 0.12	$ 0.12	$ 0.10	$ 0.08	$ 0.08
200	2.23	1.47	1.07	.83	.68	.58	.50	.45	.41	.37	.33	.31	.29
400	2.77	1.88	1.40	1.11	.93	.80	.72	.64	.58	.54	.48	.45	.43
500	3.03	2.08	1.55	1.24	1.05	.91	.81	.72	.68	.62	.56	.52	.50
600	3.30	2.27	1.73	1.38	1.16	1.03	.91	.81	.76	.70	.64	.60	.58
800	3.84	2.66	2.04	1.65	1.42	1.24	1.11	1.01	.93	.85	.80	.76	.72
1,000	4.38	3.07	2.37	1.90	1.65	1.46	1.30	1.18	1.11	1.03	.95	.89	.85
1,200	4.93	3.45	2.68	2.17	1.90	1.67	1.49	1.36	1.28	1.18	1.11	1.05	1.01
1,500	5.72	4.05	3.16	2.58	2.25	2.00	1.80	1.65	1.53	1.44	1.34	1.26	1.22

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 27. -- Continued.

D. Time and cost per M board feet (Int. scale - $\frac{1}{4}$-in.)

Skid. dist. (ft.)	Time required in hours, by tree diameter classes												
	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.43	0.27	0.19	0.14	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04
200	.90	.61	.45	.36	.30	.27	.24	.21	.20	.18	.17	.15	.15
400	1.11	.77	.59	.48	.41	.36	.33	.30	.28	.26	.24	.23	.22
500	1.22	.85	.66	.53	.46	.41	.37	.34	.32	.30	.28	.26	.25
600	1.33	.93	.72	.59	.52	.46	.42	.39	.37	.34	.32	.30	.29
800	1.55	1.09	.86	.71	.62	.56	.51	.47	.45	.42	.40	.38	.36
1,000	1.76	1.26	.99	.83	.73	.66	.60	.56	.54	.50	.47	.45	.44
1,200	1.98	1.42	1.13	.94	.84	.76	.69	.64	.62	.58	.55	.52	.51
1,500	2.31	1.66	1.33	1.12	1.00	.90	.83	.77	.75	.70	.67	.63	.62

Skid. dist. (ft.)	Estimated cost, by tree diameter classes												
0[1]	$0.83	$0.52	$0.37	$0.27	$0.21	$0.17	$0.16	$0.14	$0.12	$0.10	$0.10	$0.08	$0.08
200	1.75	1.18	.87	.70	.58	.52	.47	.41	.39	.35	.33	.29	.29
400	2.15	1.49	1.14	.93	.80	.70	.64	.58	.54	.50	.47	.45	.43
500	2.37	1.65	1.28	1.03	.89	.80	.72	.66	.62	.58	.54	.50	.48
600	2.58	1.80	1.40	1.14	1.01	.89	.81	.76	.72	.66	.62	.58	.56
800	3.01	2.11	1.67	1.38	1.20	1.09	.99	.91	.87	.81	.78	.74	.70
1,000	3.41	2.44	1.92	1.61	1.42	1.28	1.16	1.09	1.05	.97	.91	.87	.85
1,200	3.84	2.75	2.19	1.82	1.63	1.47	1.34	1.24	1.20	1.13	1.07	1.01	.99
1,500	4.48	3.22	2.58	2.17	1.94	1.75	1.61	1.49	1.46	1.36	1.30	1.22	1.20

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 28. -- Ground-skidding from stump to bunching point with winch-equipped RD 4 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-4)

A. Time and cost per 100 cubic feet.

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0 1/	0.22	0.14	0.10	0.07	0.05	0.04	0.04	0.03	0.02
100	.49	.32	.24	.18	.15	.13	.11	.09	.08
200	.58	.39	.28	.22	.18	.16	.14	.12	.10
300	.66	.45	.33	.26	.22	.19	.16	.14	.13
400	.75	.51	.38	.30	.25	.22	.19	.17	.15
500	.84	.57	.43	.34	.28	.25	.22	.19	.17
	Estimated cost, by tree diameter classes								
0 1/	$0.43	$0.27	$0.19	$0.14	$0.10	$0.08	$0.08	$0.06	$0.04
100	.95	.62	.47	.35	.29	.25	.21	.17	.16
200	1.13	.76	.54	.43	.35	.31	.27	.23	.19
300	1.28	.87	.64	.50	.43	.37	.31	.27	.25
400	1.46	.99	.74	.58	.48	.43	.37	.33	.29
500	1.63	1.11	.83	.66	.54	.48	.43	.37	.33

B. Time and cost per M board feet (Doyle-Scribner)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
	Time required in hours, by tree diameter classes								
0 1/	0.80	0.40	0.23	0.15	0.10	0.08	0.06	0.04	0.04
100	1.78	.94	.57	.39	.29	.22	.18	.14	.12
200	2.11	1.12	.69	.47	.35	.27	.22	.18	.15
300	2.43	1.30	.80	.55	.41	.33	.26	.22	.18
400	2.76	1.47	.91	.63	.47	.38	.31	.25	.21
500	3.09	1.65	1.03	.71	.54	.43	.35	.29	.25
	Estimated cost, by tree diameter classes								
0 1/	$1.55	$0.78	$0.45	$0.29	$0.19	$0.16	$0.12	$0.08	$0.08
100	3.45	1.82	1.11	.76	.56	.43	.35	.27	.23
200	4.09	2.17	1.34	.91	.68	.52	.43	.35	.29
300	4.71	2.52	1.55	1.07	.80	.64	.50	.43	.35
400	5.35	2.85	1.77	1.22	.91	.74	.60	.48	.41
500	5.99	3.20	2.00	1.38	1.05	.83	.68	.56	.48

Based on: 15 hours of operation, 178 trips, 242 tree-length logs totalling 6,557 cubic feet, average skidding distance 144 feet; estimated hourly cost of operation $1.94.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 28. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
0[1]	0.45	0.27	0.18	0.12	0.09	0.07	0.05	0.04	0.04
100	1.00	.63	.44	.32	.25	.21	.17	.14	.12
200	1.18	.75	.52	.39	.31	.26	.21	.18	.15
300	1.37	.87	.61	.46	.36	.30	.25	.21	.18
400	1.55	.99	.70	.53	.42	.35	.29	.25	.21
500	1.74	1.12	.79	.59	.48	.40	.33	.28	.24

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
0[1]	$0.87	$0.52	$0.35	$0.23	$0.17	$0.14	$0.10	$0.08	$0.08
100	1.94	1.22	.85	.62	.48	.41	.33	.27	.23
200	2.29	1.46	1.01	.76	.60	.50	.41	.35	.29
300	2.66	1.69	1.18	.89	.70	.58	.48	.41	.35
400	3.01	1.92	1.36	1.03	.81	.68	.56	.48	.41
500	3.38	2.17	1.53	1.14	.93	.78	.64	.54	.47

D. Time and cost per M board feet (Int. scale - ¼-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
0[1]	0.35	0.22	0.15	0.10	0.08	0.06	0.05	0.04	0.03
100	.78	.50	.36	.27	.22	.18	.15	.13	.11
200	.92	.60	.43	.33	.26	.22	.19	.16	.14
300	1.07	.69	.50	.38	.31	.27	.23	.19	.17
400	1.21	.79	.57	.44	.36	.31	.26	.23	.20
500	1.36	.89	.64	.50	.41	.35	.30	.26	.23

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch
0[1]	$0.68	$0.43	$0.29	$0.19	$0.16	$0.12	$0.10	$0.08	$0.06
100	1.51	.97	.70	.52	.43	.35	.29	.25	.21
200	1.78	1.16	.83	.64	.50	.43	.37	.31	.27
300	2.08	1.34	.97	.74	.60	.52	.45	.37	.33
400	2.35	1.53	1.11	.85	.70	.60	.50	.45	.39
500	2.64	1.73	1.24	.97	.80	.68	.58	.50	.45

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 29. -- Ground-skidding from stump to bunching point with winch-equipped gasoline 30 Caterpillar tractor - Caterpillar Tractor Company at Crossett. (Case C-5)

A. Time and cost per 100 cubic feet

Skid. dist. (ft.)	Time required in hours, by tree diameter classes												
	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.36	0.23	0.16	0.11	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.01
200	.72	.49	.36	.29	.24	.21	.18	.16	.14	.13	.12	.11	.10
400	.86	.59	.45	.36	.30	.27	.24	.21	.19	.17	.16	.15	.14
500	.93	.64	.49	.39	.34	.30	.26	.24	.21	.19	.18	.17	.16
600	1.00	.69	.53	.43	.37	.33	.29	.26	.24	.22	.20	.19	.18
800	1.14	.80	.61	.50	.43	.38	.35	.31	.28	.26	.24	.23	.22
1,000	1.28	.90	.70	.57	.50	.44	.40	.36	.33	.31	.29	.27	.26
1,200	1.42	1.00	.78	.64	.56	.50	.46	.41	.38	.35	.33	.31	.30

Skid. dist. (ft.)	Estimated cost, by tree diameter classes												
0 1/	$0.96	$ 0.61	$ 0.43	$ 0.29	$ 0.21	$ 0.19	$ 0.13	$ 0.11	$ 0.08	$ 0.08	$ 0.05	$ 0.05	$ 0.03
200	1.92	1.30	.96	.77	.64	.56	.48	.43	.37	.35	.32	.29	.27
400	2.29	1.57	1.20	.96	.80	.72	.64	.56	.51	.45	.43	.40	.37
500	2.47	1.70	1.30	1.04	.90	.80	.69	.64	.56	.51	.48	.45	.43
600	2.66	1.84	1.41	1.14	.98	.88	.77	.69	.64	.59	.53	.51	.48
800	3.03	2.13	1.62	1.33	1.14	1.01	.93	.82	.74	.69	.64	.61	.59
1,000	3.40	2.39	1.86	1.52	1.33	1.17	1.06	.96	.88	.82	.77	.72	.69
1,200	3.78	2.66	2.07	1.70	1.49	1.33	1.22	1.09	1.01	.93	.88	.82	.80

Based on: 77 hours of operation; 614 trips; 694 tree-length logs totalling 31,617 cubic feet; average skidding distance 271 feet; estimated hourly cost of operation $2.66.

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 29. -- Continued.

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	1.33	0.66	0.38	0.23	0.16	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02
200	2.63	1.41	.87	.60	.45	.36	.29	.24	.21	.18	.16	.14	.13
400	3.14	1.71	1.07	.74	.57	.46	.38	.32	.28	.24	.22	.20	.18
500	3.40	1.86	1.17	.82	.63	.51	.43	.36	.31	.27	.25	.23	.21
600	3.65	2.01	1.28	.89	.69	.56	.47	.40	.35	.31	.28	.25	.24
800	4.17	2.30	1.48	1.04	.81	.66	.56	.48	.42	.37	.34	.31	.29
1,000	4.68	2.60	1.68	1.19	.93	.77	.65	.56	.49	.43	.39	.36	.34
1,200	5.19	2.90	1.88	1.34	1.05	.87	.74	.63	.56	.50	.45	.42	.39

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$3.54	$ 1.76	$ 1.01	$ 0.61	$ 0.43	$ 0.29	$ 0.21	$ 0.16	$ 0.13	$ 0.11	$ 0.08	$ 0.05	$ 0.05
200	7.00	3.75	2.31	1.60	1.20	.96	.77	.64	.56	.48	.43	.37	.35
400	8.35	4.55	2.85	1.97	1.52	1.22	1.01	.85	.74	.64	.59	.53	.48
500	9.04	4.95	3.11	2.18	1.68	1.36	1.14	.96	.82	.72	.66	.61	.56
600	9.71	5.35	3.40	2.37	1.84	1.49	1.25	1.06	.93	.82	.74	.66	.64
800	11.09	6.12	3.94	2.77	2.15	1.76	1.49	1.28	1.12	.98	.90	.82	.77
1,000	12.45	6.92	4.47	3.17	2.47	2.05	1.73	1.49	1.30	1.14	1.04	.96	.90
1,200	13.81	7.71	5.00	3.56	2.79	2.31	1.97	1.68	1.49	1.33	1.20	1.12	1.04

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 29. -- Continued.

C. Time and cost per M board feet (Scribner Dec. C.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	0.75	0.45	0.29	0.20	0.14	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02
200	1.48	.95	.67	.50	.40	.33	.28	.24	.21	.18	.16	.14	.13
400	1.77	1.15	.82	.63	.51	.43	.37	.31	.27	.24	.22	.20	.19
500	1.91	1.25	.90	.69	.56	.47	.41	.35	.31	.27	.25	.23	.21
600	2.05	1.35	.97	.75	.61	.52	.45	.39	.34	.31	.28	.26	.24
800	2.34	1.55	1.13	.88	.72	.62	.54	.46	.41	.37	.34	.31	.29
1,000	2.63	1.76	1.28	1.00	.83	.71	.62	.54	.48	.43	.40	.37	.35
1,200	2.92	1.96	1.44	1.13	.94	.81	.71	.62	.55	.50	.45	.42	.40

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0 1/	$2.00	$ 1.20	$ 0.77	$ 0.53	$ 0.37	$ 0.29	$ 0.21	$ 0.16	$ 0.15	$ 0.11	$ 0.08	$ 0.05	$ 0.05
200	3.94	2.53	1.78	1.33	1.06	.88	.74	.64	.56	.48	.43	.37	.35
400	4.71	3.06	2.18	1.65	1.36	1.14	.98	.82	.72	.64	.59	.53	.51
500	5.08	3.32	2.39	1.84	1.49	1.25	1.09	.93	.82	.72	.66	.61	.56
600	5.45	3.59	2.58	2.00	1.62	1.38	1.20	1.04	.90	.82	.74	.69	.64
800	6.22	4.12	3.01	2.34	1.92	1.65	1.44	1.22	1.09	.98	.90	.82	.77
1,000	7.00	4.68	3.40	2.66	2.21	1.89	1.65	1.44	1.28	1.14	1.06	.98	.93
1,200	7.77	5.21	3.83	3.01	2.50	2.15	1.89	1.65	1.46	1.33	1.20	1.12	1.06

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 29. -- Continued.

D. Time and cost per M board feet (Int. - $\frac{1}{4}$-in.)

Skid. dist. (ft.)	10-inch	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
	Time required in hours, by tree diameter classes												
0 1/	0.58	0.36	0.23	0.16	0.12	0.09	0.07	0.06	0.04	0.03	0.03	0.02	0.02
200	1.16	.76	.54	.42	.34	.29	.25	.22	.19	.16	.15	.14	.13
400	1.38	.92	.67	.52	.43	.38	.33	.29	.26	.23	.21	.20	.18
500	1.49	1.00	.73	.58	.48	.42	.37	.32	.29	.26	.24	.22	.21
600	1.60	1.08	.80	.63	.53	.46	.41	.36	.32	.29	.27	.25	.24
800	1.83	1.24	.92	.73	.62	.54	.48	.42	.39	.35	.32	.30	.29
1,000	2.05	1.40	1.05	.84	.71	.63	.56	.49	.45	.41	.38	.36	.34
1,200	2.28	1.56	1.17	.94	.80	.71	.63	.56	.52	.47	.44	.41	.39
	Estimated cost, by tree diameter classes												
0 1/	$1.54	$ 0.96	$ 0.61	$ 0.43	$ 0.32	$ 0.24	$ 0.19	$ 0.16	$ 0.11	$ 0.08	$ 0.08	$ 0.05	$ 0.05
200	3.09	2.02	1.44	1.12	.90	.77	.66	.59	.51	.43	.40	.37	.35
400	3.67	2.45	1.78	1.38	1.14	1.01	.88	.77	.69	.61	.56	.53	.48
500	3.96	2.66	1.94	1.54	1.28	1.12	.98	.85	.77	.69	.64	.59	.56
600	4.26	2.87	2.13	1.68	1.41	1.22	1.09	.96	.85	.77	.72	.66	.64
800	4.87	3.30	2.45	1.94	1.65	1.44	1.28	1.12	1.04	.93	.85	.80	.77
1,000	5.45	3.72	2.79	2.23	1.89	1.68	1.49	1.30	1.20	1.09	1.01	.96	.90
1,200	6.06	4.15	3.11	2.50	2.13	1.89	1.68	1.49	1.38	1.25	1.17	1.09	1.04

1/ Zero distance signifies time or cost of hooking and unhooking only.

Table 30. -- Skidding with team and bummer - Crossett Lumber Co. (Case D-1)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.37	0.27	0.22	0.18	0.15	0.13	0.12	0.11	0.09	0.09	0.08	0.07
100	.83	.61	.47	.38	.32	.28	.24	.21	.19	.16	.15	.14
200	1.09	.79	.61	.49	.42	.35	.31	.27	.24	.21	.19	.17
300	1.34	.97	.75	.61	.51	.43	.37	.33	.29	.25	.23	.21
400	1.59	1.15	.89	.72	.60	.51	.44	.38	.34	.30	.26	.24

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$0.30	$0.22	$0.18	$0.15	$0.12	$0.11	$0.10	$0.09	$0.07	$0.07	$0.07	$0.06
100	.68	.50	.39	.31	.26	.23	.20	.17	.16	.13	.12	.11
200	.89	.65	.50	.40	.34	.29	.25	.22	.20	.17	.16	.14
300	1.10	.80	.62	.50	.42	.35	.30	.27	.24	.20	.19	.17
400	1.30	.94	.73	.59	.49	.42	.36	.31	.28	.25	.21	.20

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	1.07	0.66	0.45	0.33	0.26	0.21	0.18	0.15	0.13	0.12	0.11	0.10
100	2.41	1.46	.98	.72	.56	.45	.37	.31	.26	.23	.20	.18
200	3.14	1.90	1.27	.93	.72	.57	.47	.39	.33	.29	.25	.23
300	3.88	2.34	1.56	1.14	.88	.70	.57	.48	.40	.35	.30	.27
400	4.61	2.78	1.85	1.36	1.04	.82	.67	.56	.48	.41	.36	.32

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$0.88	$0.54	$0.37	$0.27	$0.21	$0.17	$0.15	$0.12	$0.11	$0.10	$0.09	$0.08
100	1.98	1.20	.80	.59	.46	.37	.30	.25	.21	.19	.16	.15
200	2.57	1.56	1.04	.76	.59	.47	.39	.32	.27	.24	.20	.19
300	3.18	1.92	1.28	.93	.72	.57	.47	.39	.33	.29	.25	.22
400	3.78	2.28	1.52	1.12	.85	.67	.55	.46	.39	.34	.30	.26

Based on: 15 hours of operation, 131 trips and 16-foot logs totalling 6,088 cubic feet, average skidding distance 214 feet, estimated hourly cost of operation $0.82.

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 30 -- Continued.

C. Time and cost per M board feet (Scribner Dec. C)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.72	0.50	0.38	0.30	0.25	0.21	0.17	0.15	0.13	0.12	0.11	0.10
100	1.63	1.12	.82	.64	.52	.43	.36	.30	.26	.23	.20	.18
200	2.12	1.45	1.07	.83	.67	.55	.46	.39	.33	.29	.26	.23
300	2.61	1.78	1.31	1.02	.82	.67	.56	.47	.40	.35	.31	.28
400	3.11	2.11	1.55	1.21	.97	.79	.65	.56	.47	.41	.36	.32

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$0.59	$0.41	$0.31	$0.25	$0.20	$0.17	$0.14	$0.12	$0.11	$0.10	$0.09	$0.08
100	1.34	.92	.67	.52	.43	.35	.30	.25	.21	.19	.16	.15
200	1.74	1.19	.88	.68	.55	.45	.38	.32	.27	.24	.21	.19
300	2.14	1.46	1.07	.84	.67	.55	.46	.39	.33	.29	.25	.23
400	2.55	1.73	1.27	.99	.80	.65	.53	.46	.39	.34	.30	.26

D. Time and cost per M board feet (Int. Scale - $\frac{1}{4}$-in.)

Time required in hours, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	0.57	0.41	0.32	0.25	0.22	0.18	0.16	0.14	0.13	0.11	0.10	0.10
100	1.29	.91	.69	.55	.46	.38	.33	.29	.25	.22	.20	.18
200	1.69	1.19	.89	.71	.59	.49	.42	.36	.32	.28	.25	.23
300	2.08	1.46	1.10	.87	.72	.60	.51	.44	.38	.34	.30	.27
400	2.46	1.74	1.30	1.03	.85	.71	.60	.52	.45	.39	.35	.32

Estimated cost, by tree diameter classes

Skid. dist. (ft.)	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch
0[1]	$0.47	$0.34	$0.26	$0.20	$0.18	$0.15	$0.13	$0.11	$0.11	$0.09	$0.08	$0.08
100	1.06	.75	.57	.45	.38	.31	.27	.24	.20	.18	.16	.15
200	1.39	.98	.73	.58	.48	.40	.34	.30	.26	.23	.20	.19
300	1.71	1.20	.90	.71	.59	.49	.42	.36	.31	.28	.25	.22
400	2.02	1.43	1.07	.84	.70	.58	.49	.43	.37	.32	.29	.26

[1] Zero distance signifies time or cost of hooking and unhooking only.

Table 31. -- Bunching logs and loading trucks with "Speeder Loader" mounted on Diesel 40 Caterpillar tractor - W. T. Smith Lumber Company. (Case D-2)

A. Time and cost per 100 cubic feet.

Time required in hours, by tree diameter classes	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch	36-inch
Bunching 1/ and loading	0.38	0.30	0.25	0.22	0.19	0.18	0.16	0.15	0.14	0.14	0.13	0.12	0.12
Loading only	.20	.16	.13	.11	.09	.08	.08	.07	.06	.06	.06	.05	.05
Estimated cost, by tree diameter classes													
Bunching 1/ and loading	$0.85	$0.67	$0.56	$0.49	$0.43	$0.40	$0.36	$0.34	$0.31	$0.31	$0.29	$0.27	$0.27
Loading only	.45	.36	.29	.25	.20	.18	.18	.16	.13	.13	.13	.11	.11

B. Time and cost per M board feet (Doyle-Scribner)

Time required in hours, by tree diameter classes	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch	36-inch
Bunching 1/ and loading	1.11	0.72	0.52	0.40	0.33	0.28	0.25	0.22	0.20	0.19	0.17	0.16	0.16
Loading only	0.59	.30	.26	.20	.16	.14	.12	.10	.09	.08	.08	.07	.07
Estimated cost, by tree diameter classes													
Bunching 1/ and loading	$2.49	$1.61	$1.16	$0.90	$0.74	$0.63	$0.56	$0.49	$0.45	$0.43	$0.38	$0.36	$0.36
Loading only	1.32	.67	.58	.45	.36	.31	.27	.22	.20	.18	.18	.16	.16

C. Time and cost per M board feet (Scribner Dec. C.)

Time required in hours, by tree diameter classes	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch	36-inch
Bunching 1/ and loading	0.75	0.55	0.43	0.36	0.31	0.27	0.24	0.22	0.20	0.19	0.17	0.17	0.16
Loading only	.40	.29	.22	.18	.15	.13	.11	.10	.09	.08	.08	.07	.07
Estimated cost, by tree diameter classes													
Bunching 1/ and loading	$1.68	$1.23	$0.96	$0.81	$0.69	$0.60	$0.54	$0.49	$0.45	$0.43	$0.38	$0.38	$0.36
Loading only	.90	.65	.49	.40	.34	.29	.25	.22	.20	.18	.18	.16	.16

D. Time and cost per M board feet (Int. scale - ¼-in.)

Time required in hours, by tree diameter classes	12-inch	14-inch	16-inch	18-inch	20-inch	22-inch	24-inch	26-inch	28-inch	30-inch	32-inch	34-inch	36-inch
Bunching 1/ and loading	0.59	0.45	0.36	0.31	0.27	0.24	0.22	0.21	0.19	0.18	0.17	0.16	0.16
Loading only	.32	.23	.18	.15	.13	.12	.10	.09	.09	.08	.07	.07	.07
Estimated cost, by tree diameter classes													
Bunching 1/ and loading	$1.32	$1.01	$0.81	$0.69	$0.60	$0.54	$0.49	$0.47	$0.43	$0.40	$0.38	$0.36	$0.36
Loading only	.72	.52	.40	.34	.29	.27	.22	.20	.20	.18	.16	.16	.16

Based on: 28 hours of operation, 564 logs 12 to 24 feet long totalling 15,190 cubic feet, estimated hourly cost for loader and crew $2.24 (cost of truck time consumed is not included).

1/ Time and cost for bunching shown here are for bunching 78 percent of the logs for 41 feet each - which conforms to the woods conditions encountered.

Table 32. -- Loading logs on log cars with Barnhardt car-top loader - Crossett Lumber Company (Case D-3)

D.b.h.	Loading time				Estimated cost			
	Per 100 cu.ft.	Per M bd.ft. (Doyle-Scrib)	Per M bd.ft. (Scrib.Dec.C)	Per M bd.ft. (Int.-$\frac{1}{4}$-in.)	Per 100 cu.ft.	Per M bd.ft. (Doyle-Scrib)	Per M bd.ft. (Scrib.Dec.C)	Per M bd.ft. (Int.-$\frac{1}{4}$-in.)
(Inches)	Hours	Hours	Hours	Hours				
12	0.038	0.111	0.075	0.060	$0.11	$0.32	$0.22	$0.18
14	.028	.067	.051	.042	.08	.20	.15	.12
16	.021	.043	.036	.031	.06	.13	.11	.09
18	.017	.032	.029	.025	.05	.09	.08	.07
20	.014	.024	.023	.020	.04	.07	.07	.06
22	.012	.019	.019	.017	.04	.06	.06	.05
24	.011	.016	.016	.014	.03	.05	.05	.04
26	.009	.014	.014	.013	.03	.04	.04	.04
28	.008	.012	.012	.011	.02	.04	.04	.03
30	.007	.010	.010	.010	.02	.03	.03	.03
32	.007	.009	.009	.009	.02	.03	.03	.03
34	.006	.008	.008	.008	.02	.02	.02	.02

Basis: 22 hours of operation; 151 loads; estimated hourly cost $2.92.

Table 33. -- Hooking and unhooking for all cases

A. Time and cost per 100 cubic feet

Case no.	Time required in hours, by tree-diameter groups						Estimated cost, by tree-diameter groups					
	12-inch	16-inch	20-inch	24-inch	28-inch	32-inch	12-inch	16-inch	20-inch	24-inch	28-inch	32-inch
Arch-skidding tractors												
A-1	0.33	0.19	0.13	0.10	0.08	0.06	$1.29	$0.74	$0.51	$0.39	$0.31	$0.23
A-2	.17	.10	.07	.06	.05	.04	.66	.39	.27	.23	.20	.16
A-3	.19	.11	.08	.06	.05	--	.75	.43	.32	.24	.20	--
A-4	.30	.17	.12	.10	.08	.07	.98	.56	.39	.33	.26	.23
Pan-skidding tractors												
B-1	.21	.10	.06	.04	--	--	.68	.33	.20	.13	--	--
B-2	.11	.08	.07	.06	--	--	.28	.20	.18	.15	--	--
Ground-skidding tractors												
C-1	.26	.12	.08	.06	.03	.03	.60	.28	.18	.14	.07	.07
C-2	.14	.07	.04	.03	--	--	.32	.16	.09	.07	--	--
C-3	.18	.10	.07	.05	.04	.03	.35	.19	.14	.10	.08	.06
C-4	.14	.07	.04	.03	--	--	.27	.14	.08	.06	--	--
C-5	.23	.11	.07	.04	.03	.02	.61	.29	.19	.11	.08	.05
Other equipment[1]												
D-1	.37	.22	.15	.12	.09	.08	.30	.18	.12	.10	.07	.07
D-2	.20	.13	.09	.08	.06	.06	.45	.29	.20	.18	.13	.13
D-3	.04	.02	.01	.01	.01	.01	.11	.06	.04	.03	.02	.02

B. Time and cost per M board feet (Doyle-Scribner)

Case no.	Time required in hours, by tree-diameter groups						Estimated cost, by tree-diameter groups					
Arch-skidding tractors												
A-1	0.94	0.39	0.22	0.15	0.11	0.09	$3.67	$1.52	$0.86	$0.58	$0.43	$0.35
A-2	.50	.21	.13	.09	.07	.06	1.95	.82	.51	.35	.27	.23
A-3	.54	.22	.13	.09	.07	--	2.13	.87	.51	.35	.28	--
A-4	.86	.36	.21	.15	.12	.10	2.81	1.18	.69	.49	.39	.33
Pan-skidding tractors												
B-1	.60	.21	.10	.06	--	--	1.96	.68	.33	.20	--	--
B-2	.32	.17	.12	.10	--	--	.81	.43	.30	.25	--	--
Ground-skidding tractors												
C-1	.75	.26	.14	.08	.04	.04	1.73	.60	.32	.18	.09	.09
C-2	.39	.14	.08	.05	--	--	.88	.32	.18	.11	--	--
C-3	.51	.20	.11	.08	.06	.04	.99	.39	.21	.16	.12	.08
C-4	.40	.15	.08	.04	--	--	.78	.29	.16	.08	--	--
C-5	.66	.23	.11	.06	.04	.02	1.76	.61	.29	.16	.11	.05
Other equipment[1]												
D-1	1.07	.45	.26	.18	.13	.11	.88	.37	.21	.15	.11	.09
D-2	.59	.26	.16	.12	.09	.08	1.32	.58	.36	.27	.20	.18
D-3	.11	.04	.02	.02	.01	.01	.32	.13	.07	.05	.04	.03

[1] Time and cost for cases D-2 and D-3 are for loading; they are presented here for comparison with hooking and unhooking cost in skidding.

Table 34. -- Estimated hourly cost involved in operating specified tractor-skidding equipment, wages on the "common" wage base of the present southern tractor logging cost inquiry

Item of cost	60 hp gas tractor without winch		60 hp gas tractor with winch		60 hp gas tractor with winch and arch		75 hp diesel tractor with winch and arch	
Initial cost	$4,600		$6,000		$8,000		$11,600	
Average investment	2,760		3,600		4,800		6,760	
		Percent		Percent		Percent		Percent
A. Current operating cost								
1. Direct labor cost								
Driver, 1 at 40 cents	$0.40	11.4	$0.40	10.2	$0.40	8.6	$0.40	9.9
Helpers, 2 at $27\frac{1}{2}$ cents	.55	15.7	.55	13.9	.55	12.0	.55	13.5
Unhooker (chaser), 1/3 at $27\frac{1}{2}$ cents	.09	2.6	.09	2.3	.09	1.9	.09	2.2
Insurance (industrial and unemployment)	.03	.9	.03	.8	.03	.6	.03	.7
Total direct labor cost	1.07	30.6	1.07	27.2	1.07	23.1	1.07	26.3
2. Other direct cost								
Fuel	.90	25.6	.90	22.8	1.20	25.9	.30	7.4
Lubricating oil	.05	1.4	.05	1.3	.07	1.5	.07	1.7
Grease	.04	1.1	.04	1.0	.06	1.3	.06	1.5
Service labor	.06	1.7	.06	1.5	.06	1.3	.06	1.5
Cable and rigging	.10	2.8	.20	5.1	.25	5.4	.30	7.4
Repair parts and labor	.50	14.3	.65	16.5	.70	15.0	.70	17.2
Transportation of crew	.06	1.7	.06	1.5	.06	1.3	.06	1.5
Supervision	.13	3.7	.13	3.3	.13	2.8	.13	3.2
Total other direct cost	1.84	52.3	2.09	53.0	2.53	54.5	1.68	41.4
B. Ownership cost								
Depreciation (life of gas tractors, 10,000 hours; diesel tractors, 12,000 hours)	.46	13.1	.60	15.2	.80	17.2	.97	23.9
Interest, taxes, fire insurance and uninsured risks (per hour = 0.005 percent of average investment)	.14	4.0	.18	4.6	.24	5.2	.34	8.4
Total ownership cost	.60	17.1	.78	19.8	1.04	22.4	1.31	32.3
GRAND TOTAL	3.51	100.0	3.94	100.0	4.64	100.0	4.06	100.0

Table 35. -- After-logging inventory of trees according to kind of injury on 240 acres of the Crossett tractor logging area.

Class	Pine 5-in. diameter and larger		Hardwoods 9-in. diameter and larger		Pine and hardwoods	
	Number	Percent	Number	Percent	Number	Percent
Total	13,415	100	3,910	100	17,325	100
Uninjured	10,914	81	2,439	62	13,353	77
Injured but living, Dec. 1936						
Felling injury	727	5	514	13	1,241	7
Skidding injury	819	6	376	10	1,195	7
Dead, December 1936						
Felling injury	900	7	546	14	1,446	8
Skidding injury	55	1	35	1	90	1

FIGURES

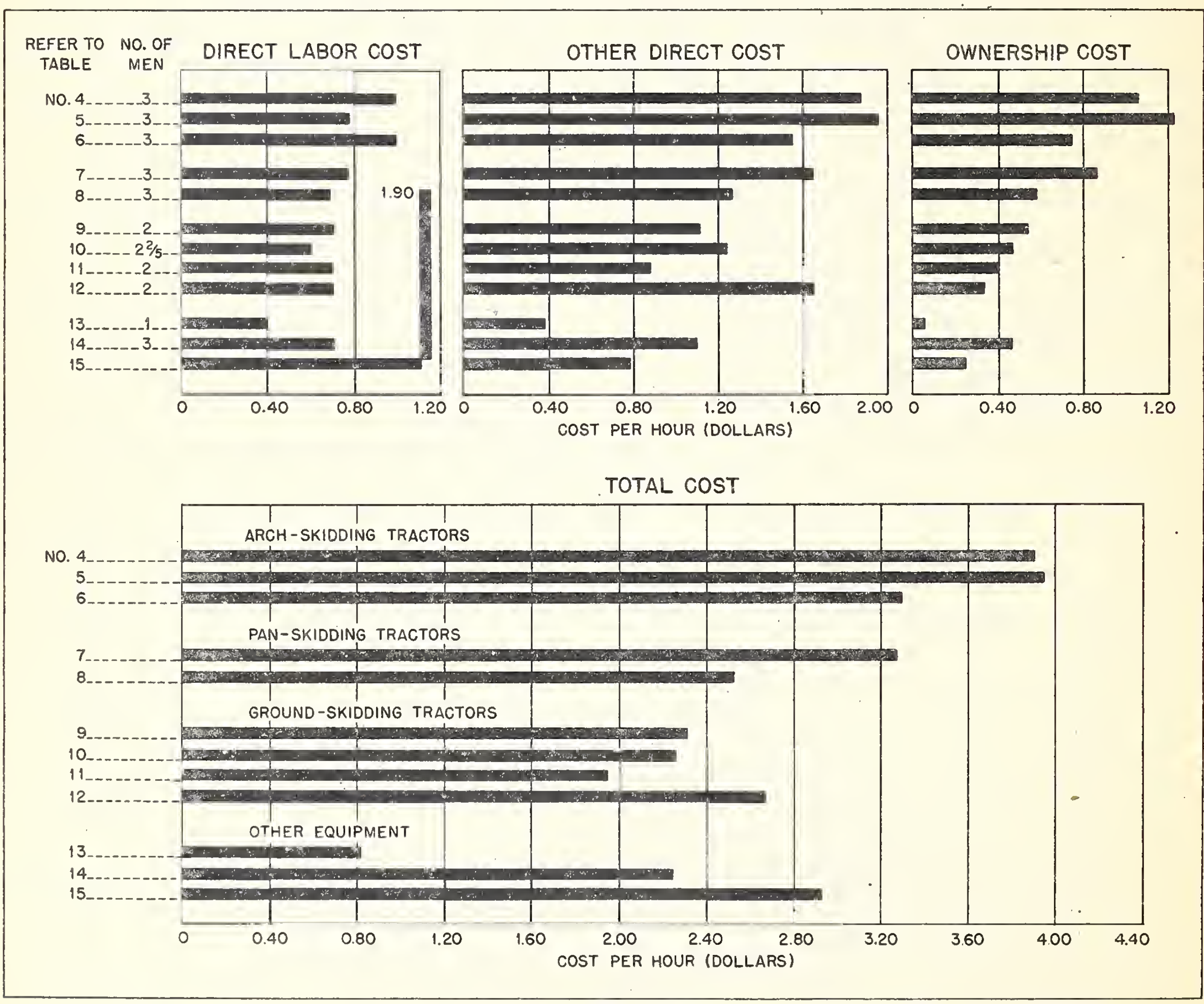


FIG. 1- HOURLY COST INVOLVED IN USE OF DIFFERENT LOGGING EQUIPMENT

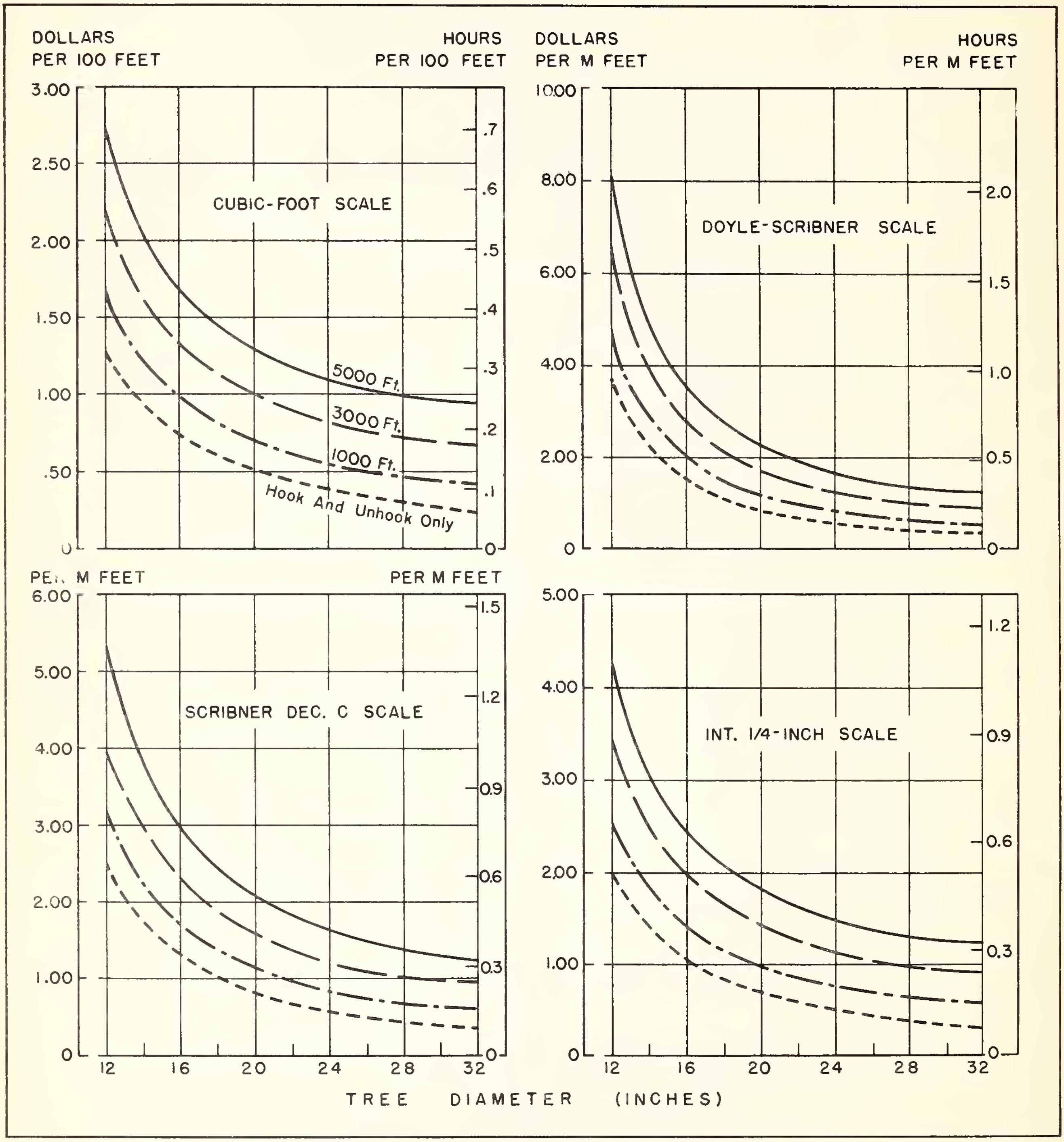


FIG-2 ARCH-SKIDDING FROM STUMP TO RAILROAD WITH WINCH-EQUIPPED RD7 CATERPILLAR TRACTOR AND 10-TON ARCH – CATERPILLAR TRACTOR COMPANY AT CROSSETT (CASE A-1)

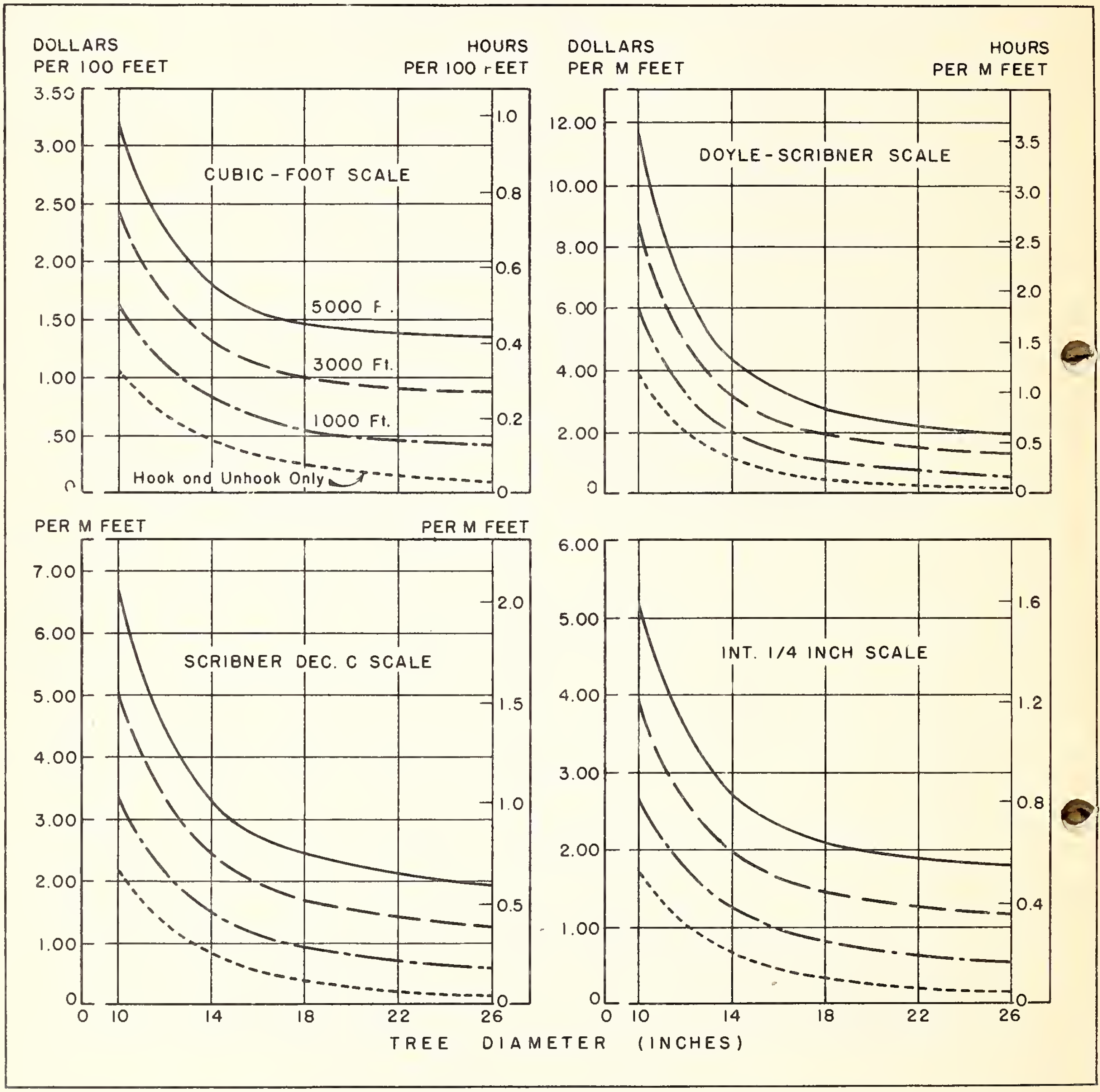


FIG. 3 - PAN-SKIDDING FROM STUMP TO RAILROAD WITH WINCH-EQUIPPED RD7 CATERPILLAR TRACTOR AND SKIDDING PAN - BROOKS-SCANLON CORPORATION (CASE B-1)

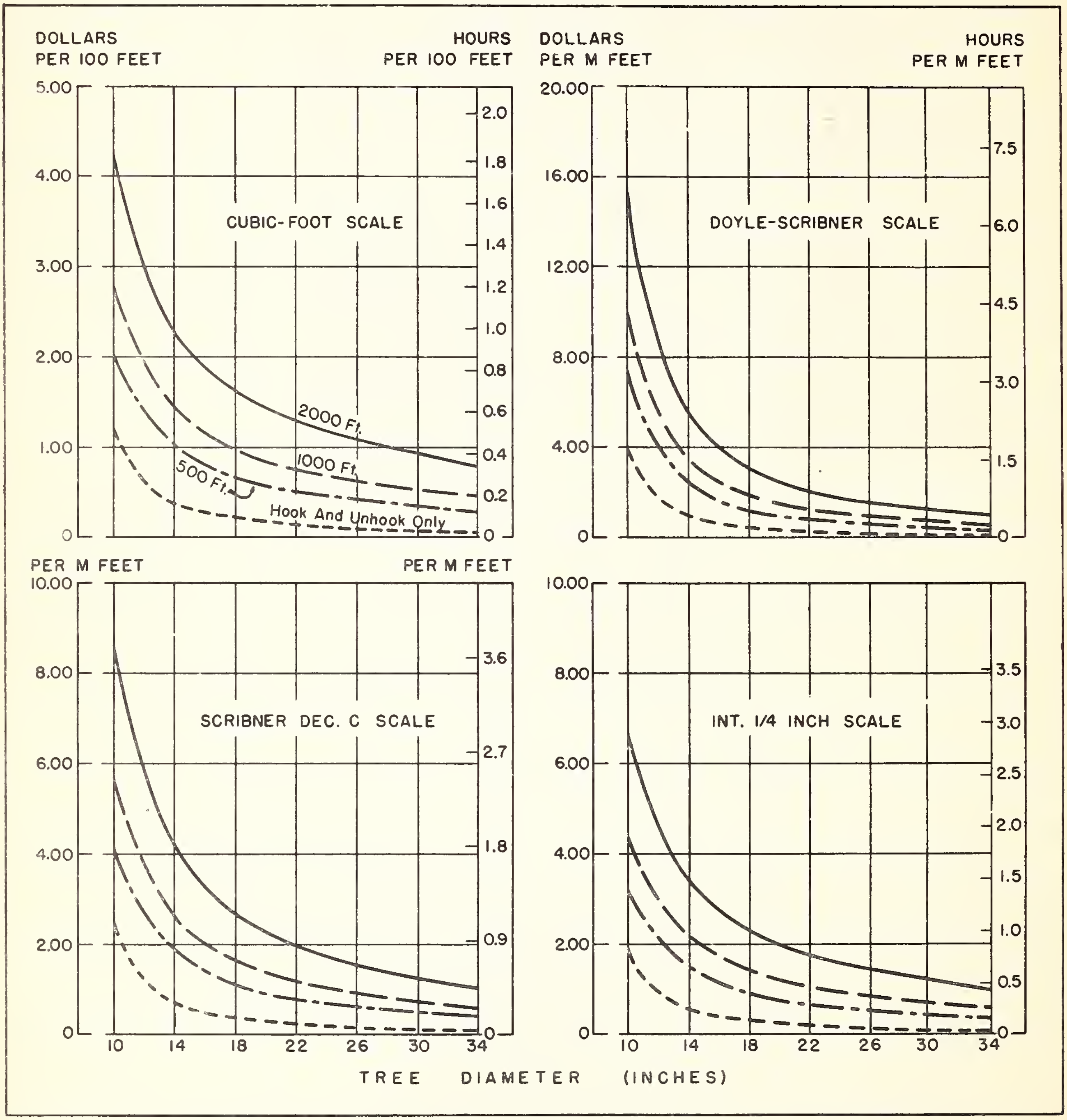


FIG. 4 - GROUND-SKIDDING FROM STUMP TO RAILROAD WITH WINCH-EQUIPPED RD6 CATERPILLAR TRACTOR - CATERPILLAR TRACTOR COMPANY AT CROSSETT (CASE C-1)

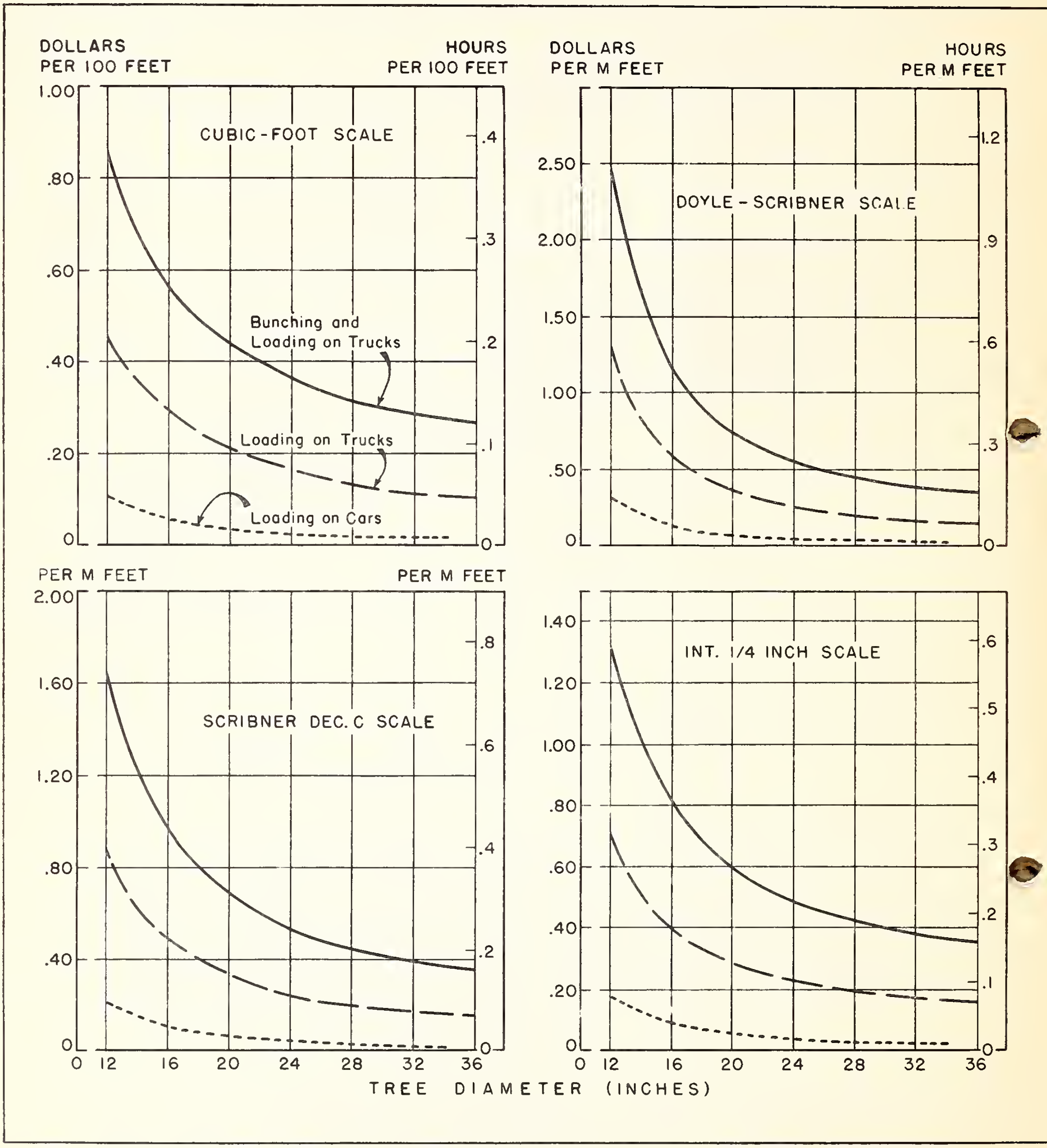
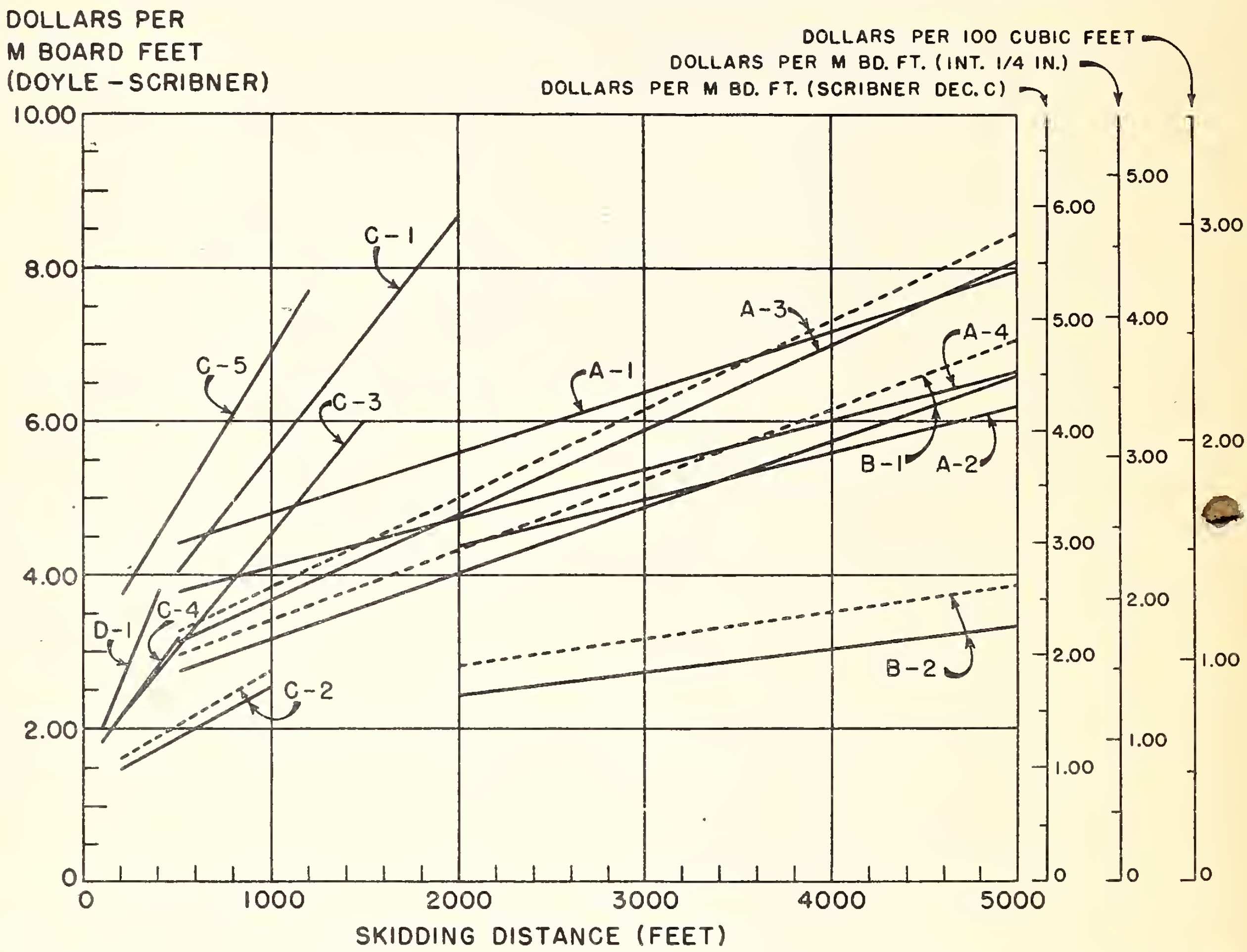


FIG. 5 - COST OF BUNCHING AND LOADING, AND LOADING ONLY, ON TRUCKS, AND LOADING ON CARS, BY TREE SIZE. BUNCHING AND LOADING ON TRUCKS WAS DONE WITH SPEEDER LOADER[1]; LOADING ON CARS WITH BARNHARDT CAR-TOP LOADER[2]. SCALE ON RIGHT-HAND SIDE OF EACH GRAPH GIVES TIME IN HOURS FOR SPEEDER LOADER ONLY.

(1) CASE D-2 (2) CASE D-3



	Arch - Skidding Troctors				Pon - Skidding Troctors		Ground Skidding Troctors					Other Equip.
Cose No.	A – 1	A – 2	A – 3	A – 4	B – 1	B – 2	C – 1	C – 2	C – 3	C – 4	C – 5	D – 1
Equipment	RD7	RD7	D50	RD6	RD7	RD6	RD6	MD 40	RD4	RD4	Gos 30	Teom
Operotor	CT Co.	CT Co.	BS Co.	CT Co.	BS Co.	JL Co.	CT Co.	PRVL Co.	CT Co.	CT Co.	CT Co.	CL Co.
Type of Houl*	S to RR	BP to RR	S to RR	S to RR	S to RR	S to RR	S to RR	S to RR	S to RR	S to BP	S to BP	S to RR
Hourly Rote ($)	3.90	3.90	3.94	3.27	3.26	2.52	2.31	2.25	1.94	1.94	2.66	0.82

* S = stump BP = bunching point RR = roilrood

FIG. 6 – ESTIMATED COST OF SKIDDING 12-INCH TREES FOR SPECIFIED DISTANCES AND TYPES OF EQUIPMENT. DOTTED LINES INDICATE ADJUSTED COST BASED ON A COMMON WAGE SCALE.

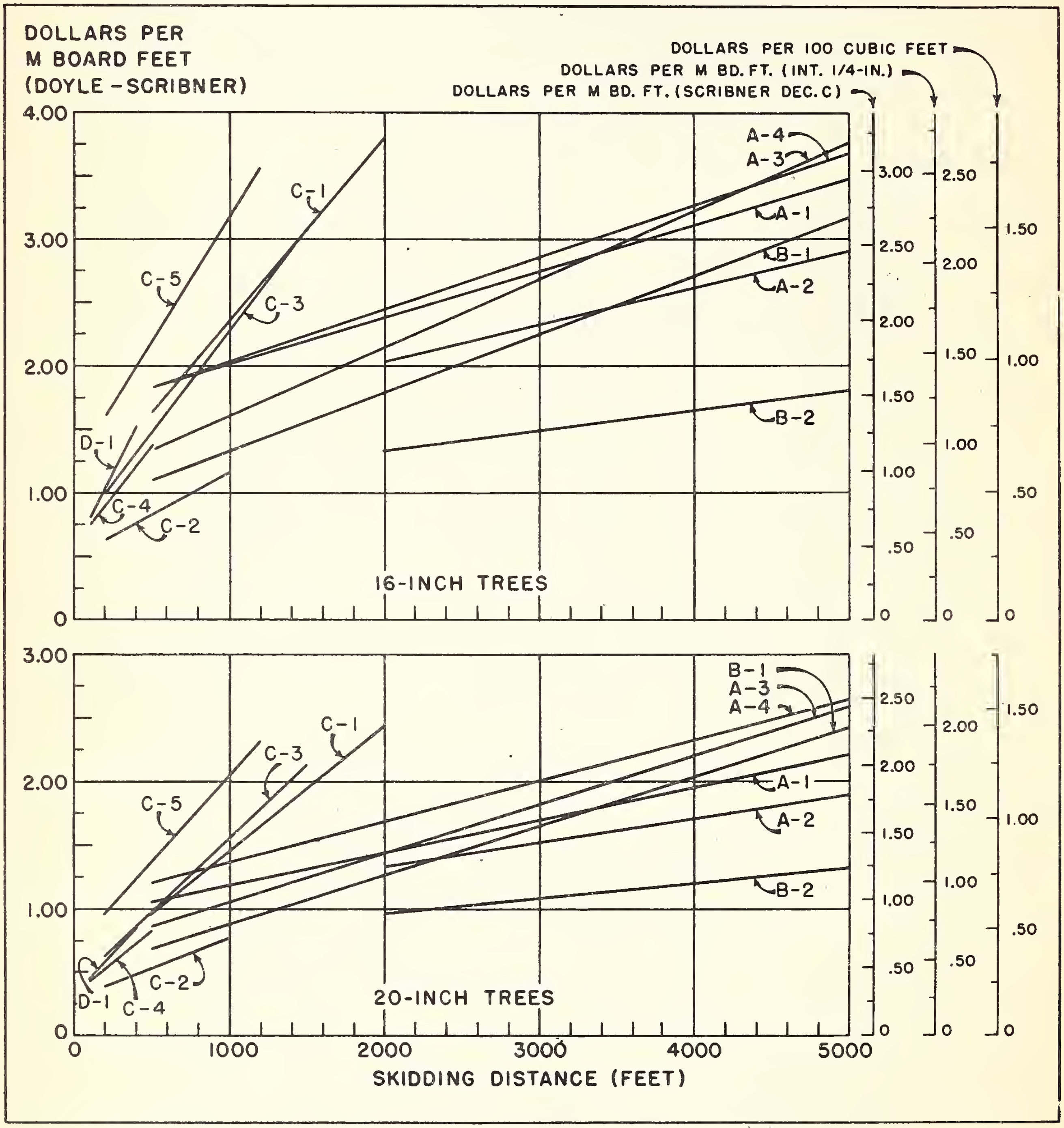


FIG. 7 - ESTIMATED COST OF SKIDDING 16 AND 20-INCH TREES FOR SPECIFIED DISTANCES AND TYPES OF EQUIPMENT.

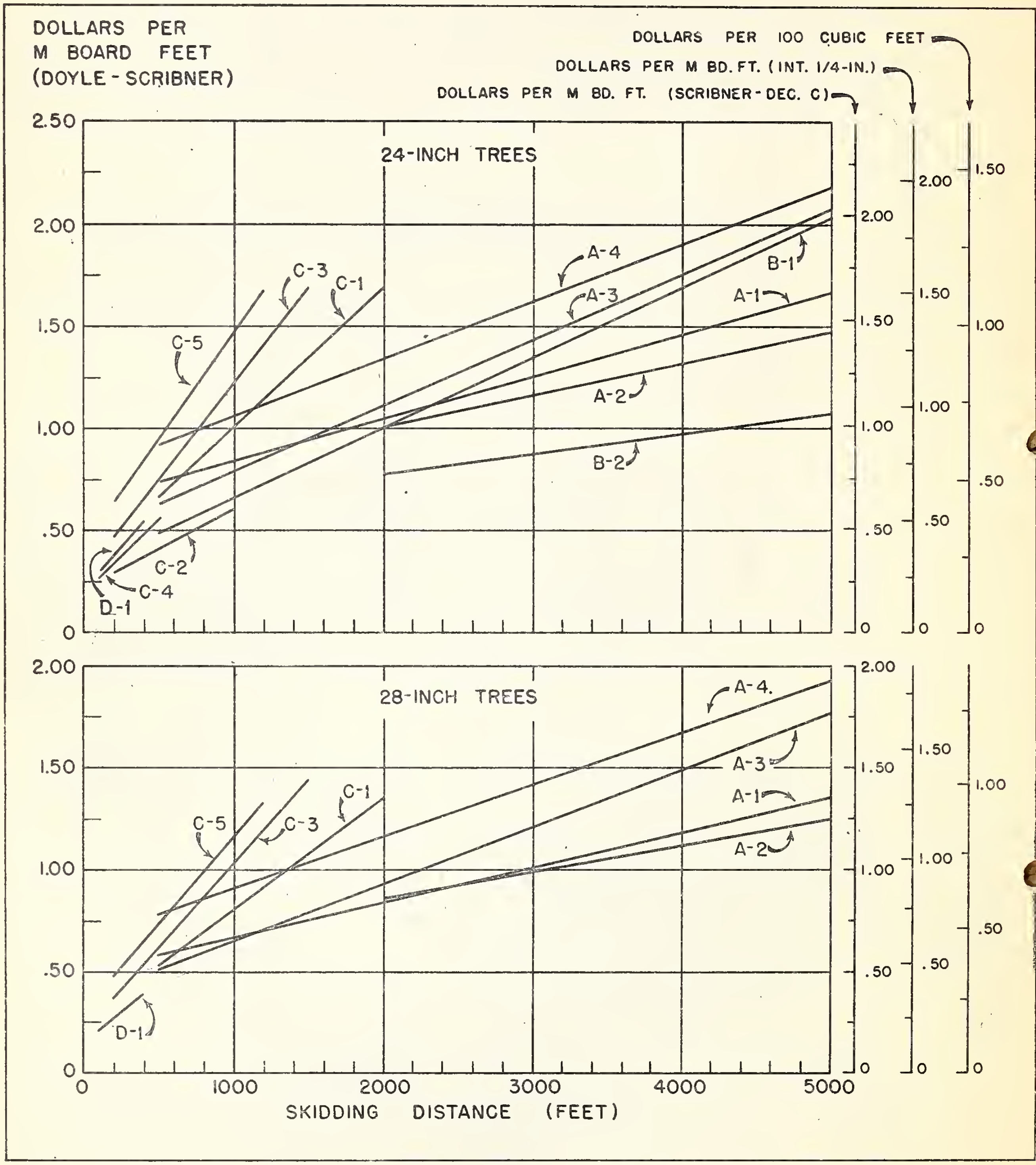
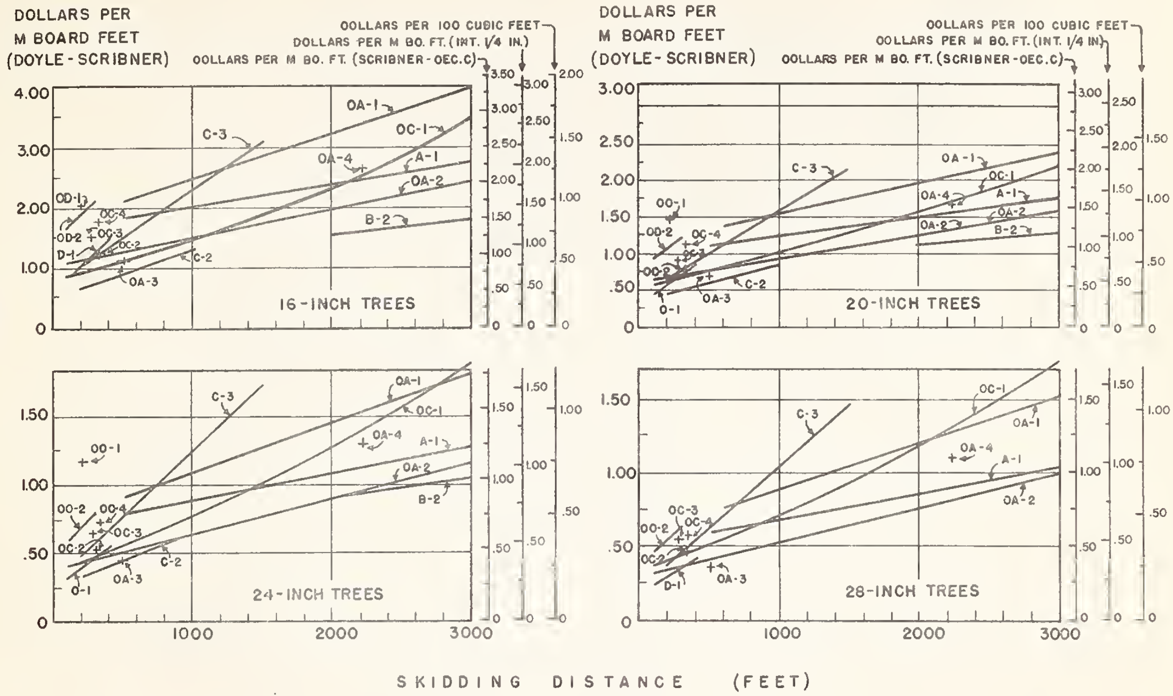


FIG. 8 - ESTIMATED COST OF SKIDDING 24 AND 28 - INCH TREES FOR SPECIFIED DISTANCES AND TYPES OF EQUIPMENT.



	ARCH-SKIDDING TRACTORS					PAN-SKIDDING TRACTORS	GROUND-SKIDDING TRACTORS						SKIDDING TEAMS		
Case No.	A-1	OA-1	OA-2	OA-3	OA-4	B-2	C-2	C-3	OC-1	OC-2	OC-3	OC-4	D-1	OD-1	OD-2
Equipment	RD-7	Gas 60	Diesel 75	Diesel 75	Gas 60	RD-6	MD-40	RD-4	10-T Holt	Gas 60	Gas 60	Gas 60	Horses		
Locality	S.E. Ark.	W. Wash.	E. Oreg.	E. Oreg.	E. Oreg.	S. Alab.	Miss.	Ark.	Mont.	E. Oreg.	E. Oreg.	E. Oreg.	Ark.	Maine	E. Oreg.
Species	So. Pine	D. Fir	P. Pine	P. Pine	P. Pine	S. Pine	S. Pine	S. Pine	P. Pine	P. Pine	P. Pine	P. Pine	S. Pine	W. Pine	P. Pine
Slope	Level	Level	+	+	+	Level	Level	Level	0-15%	+	Level	Level	Level	?	Level
Hourly rate ($)	3.90	4.64	4.06	4.06	4.64	2.91	2.47	1.94	3.51	3.94	3.94	3.94	.82	1.01	.82
Record from	Present Report	Br'dst'm	Br'dst'm	Br'dst'm	Br'dst'm	Present Report	Present Report	Present Report	Bradner	Br'dst'm	Br'dst'm	Br'dst'm	Present Report	F.P.L.	Br'dst'm
Year	1936	1931	1935	1935	1935	1936	1936	1936	1922	1935	1935	1935	1936	1935	1935

NOTE: EQUIPMENT:

All tractors built by Caterpillar Tractor Co. except MD 40 built by McCormick-Deering (International Harvester Co.) and 10-Ton Holt built by Holt Tractor Co.

SPECIES:

S. Pine = Southern Pine; D. Fir = Douglas Fir; P. Pine = Ponderosa Pine; W. Pine = Eastern White Pine.

SLOPE:

Level = No appreciable slope; + = Grade (percent not stated) favorable to load; ? = Grade not stated, presumably level or favorable to the load.

RECORD FROM:

Br'dst'm = A.J.F. Brandstrom, all unpublished data save case OA-1 from A.J.F. Brandstrom, Analysis of logging costs and operating methods in the Douglas Fir region; Bradner = M. Bradner et al., An analysis of log production in the "Inland Empire" region. U.S. Department of Agriculture Tech. Bul. 355, 1933; F.P.L. = U.S. Forest Products Laboratory, White pine production cost and method studies in New England (Study No. 3) 1935, Unpublished manuscript.

FIG. 9 - ESTIMATED COST OF SKIDDING 16-, 20-, 24-, AND 28-INCH TREE FOR SPECIFIED DISTANCES AND TYPES OF EQUIPMENT. THE LETTER "O" IN CERTAIN CASE NUMBERS INDICATES THE INFORMATION IS FROM A SOURCE OTHER THAN THE WOODS WORK OF THE PRESENT INQUIRY. THE INFORMATION ON OUTPUT IS ADJUSTED TO WEIGHT AND VOLUME OF PINE TREES AT CROSSETT, ARK. ALL WAGES ARE ON THE COMMON WAGE SCALE USED IN THE PRESENT LOGGING REPORT.

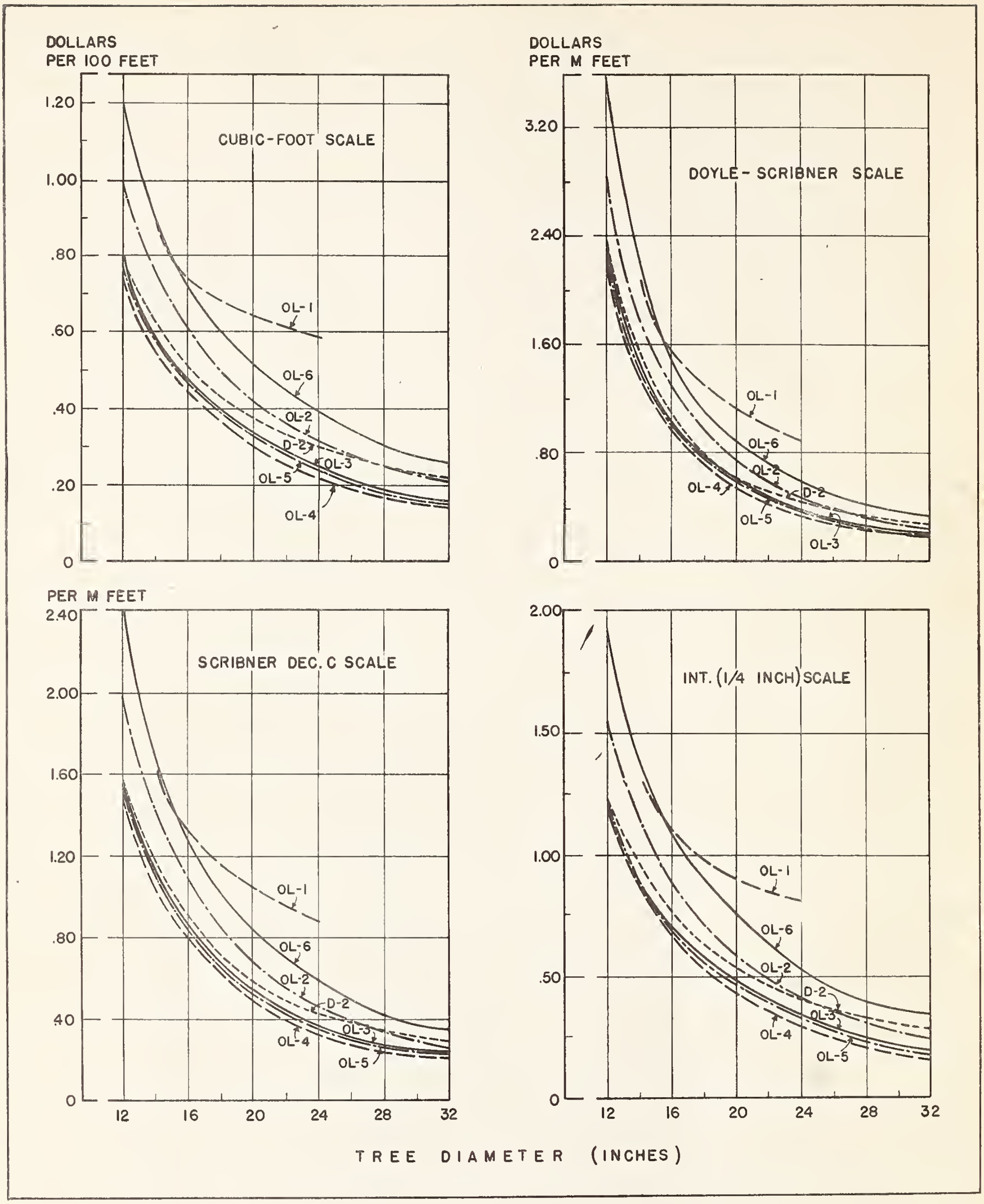


FIG. 10 - ESTIMATED COST OF LOADING TRUCKS WITH 16-FOOT LOGS FROM TREES OF SPECIFIED DIAMETERS FOR CERTAIN TYPES OF LOADING EQUIPMENT (COST OF TRUCK TIME IS INCLUDED). THE LETTER "O" IN CASE NUMBERS INDICATES THE INFORMATION IS FROM A SOURCE OTHER THAN THE WOODS WORK OF THE PRESENT INQUIRY. THE INFORMATION ON OUTPUT IS ADJUSTED TO THE WEIGHT AND VOLUME OF PINE TREES AT CROSSETT, ARKANSAS. THE WAGE ELEMENT OF ALL COSTS CONFORMS TO THE COMMON WAGE BASE OF THE PRESENT REPORT.

(SEE EXPLANATORY NOTES ON THE PAGE TO THE LEFT.)

Explanatory Notes for Figure 10

	Cross-haul Loader	Boom Loaders					
		Sled-mount	Converted power shovels				Tractor-mount
Case No.	OL-1	OL-2	OL-3	OL-4	OL-5	OL-6	D-2
Equipment	Team	85 hp motor	3/4-yd. diesel	3/4-yd. diesel	3/4-yd. gaso-line	1/2-yd. gaso-line	Speeder Loader
Locality	S.Ark.	E.Oreg.	E.Oreg.	E.Oreg.	E.Oreg.	E.Oreg.	S. Ala.
Species	S.pine	P.pine	P.pine	P.pine	P.pine	P.pine	S. pine
Hourly Rate: Ldg. Eqpt. ($)	0.82	1.98	2.80	2.80	3.38	2.94	2.51
Truck Eqpt. ($)	1.33	1.44	1.44	1.44	1.44	1.44	1.44
Total ($)	2.15	3.42	4.24	4.24	4.82	4.38	3.95
Record From	RRR	AJFB	AJFB	AJFB	AJFB	AJFB	Present Report
Year	1934-5	1935	1935	1935	1935	1935	1936

Species: S. pine = Southern pine; P. pine = Ponderosa pine.

Record from: RRR = R.R.Reynolds, U. S. Forest Service, Branch of Research, Monthly Report February 1937, pp. 22-23.

AJFB = A.J.F.Brandstrom, Pacific Northwest Forest and Range Experiment Station, U. S. Forest Service, unpublished data.